MECHANICAL ENGINEERING

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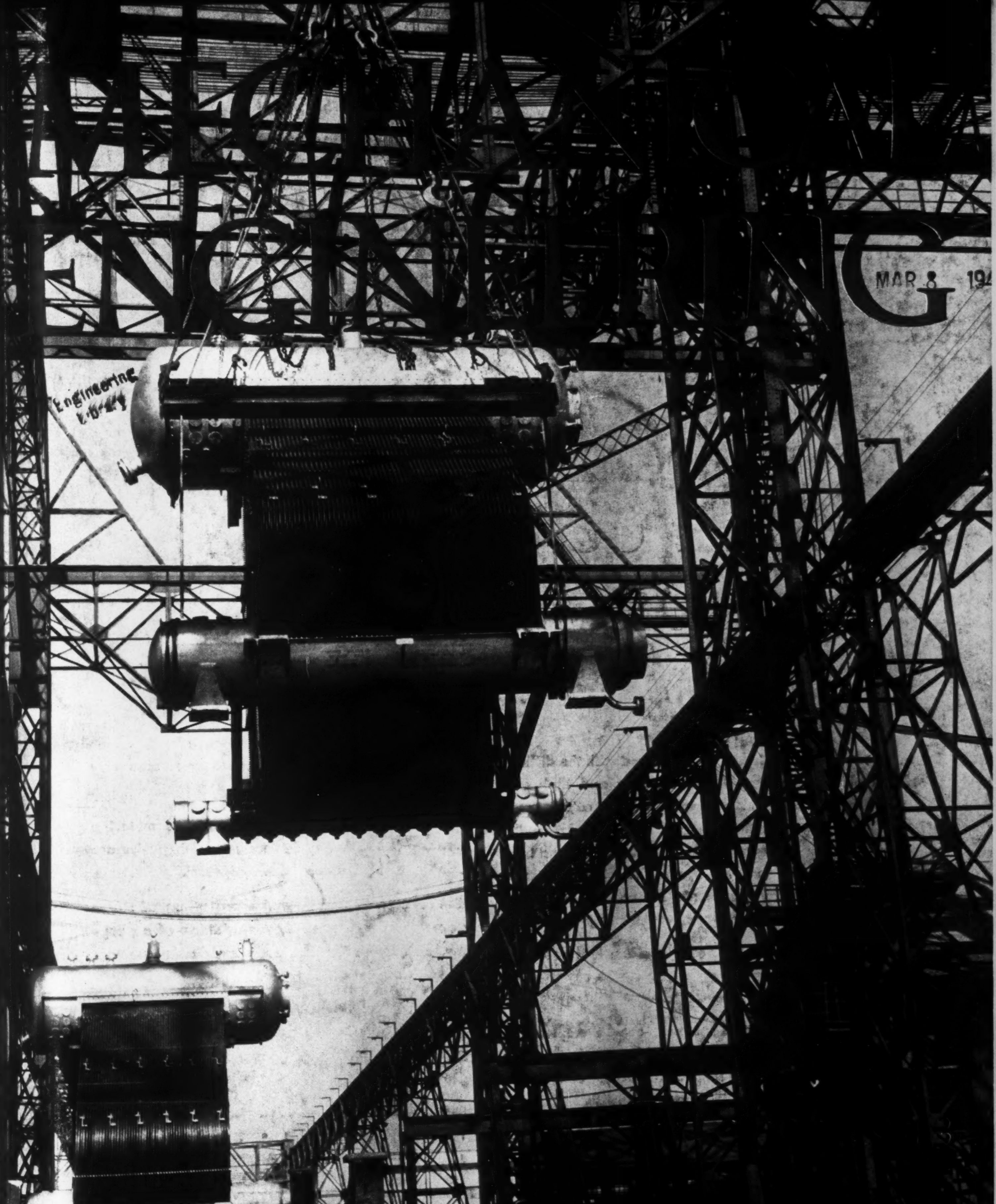

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MECHANICAL ENGINEERING

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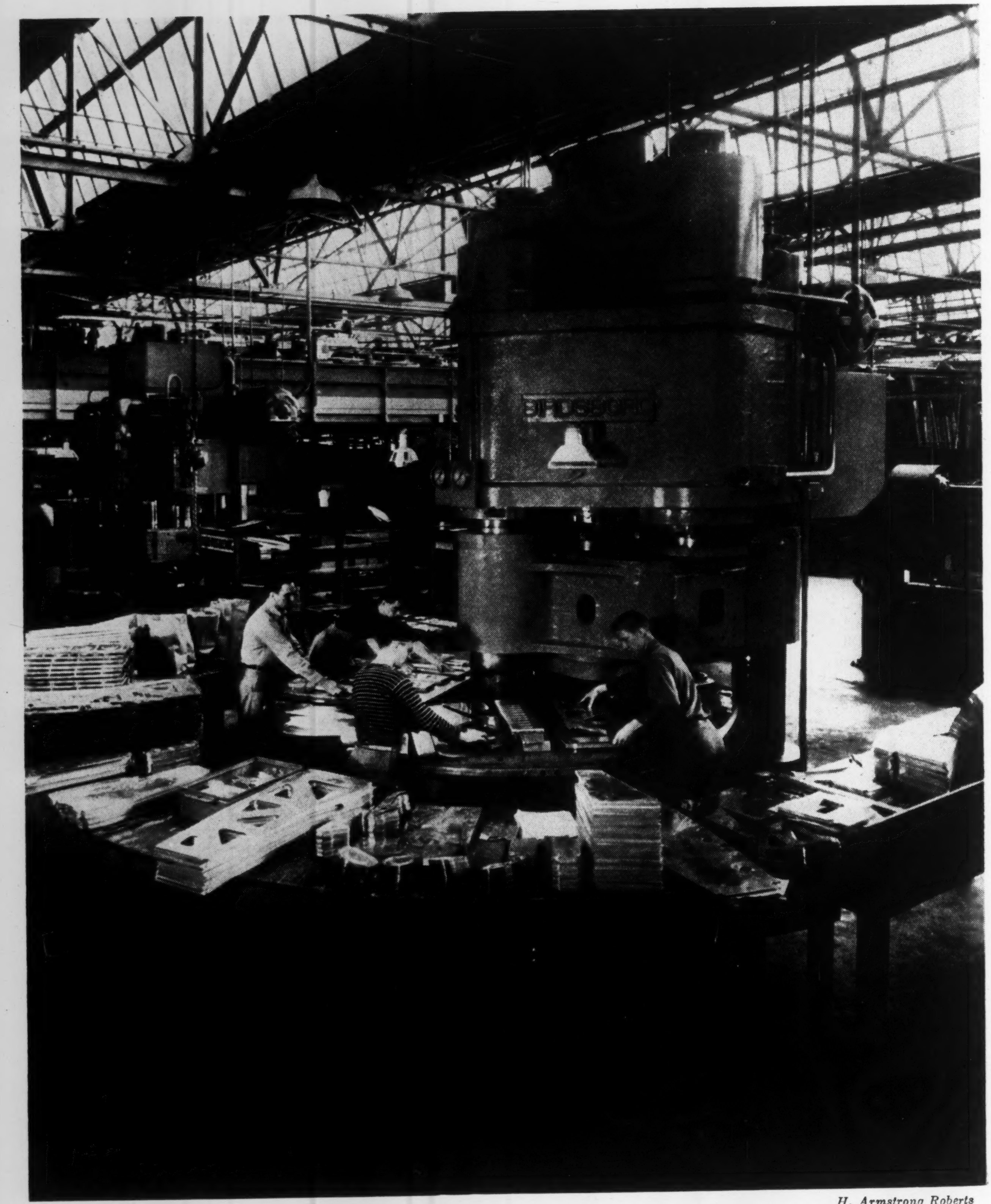

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Volume 65
No. 3

MECHANICAL ENGINEERING

March
1943

GEORGE A. STETSON, *Editor*

The Navy Needs Engineers

FOR more than a year it has been clear that the global war in which this nation is engaged will demand the active support of practically every citizen and will eliminate or force into a very subordinate position every business and organized activity that does not primarily contribute to the winning of the war. In these columns last spring it was suggested that, before compulsion became necessary, every plant should find some way of making itself useful in providing the essential goods and services needed by the nation and every engineer should see to it that his own services were being most usefully employed.

Recent announcements by the War Manpower Commission indicate that the day of compulsion is drawing near. In the meantime opportunities for helping to win the war have been increasing. In many cases some personal sacrifice will be entailed but such sacrifices are a small price to pay for the preservation of our nation and our way of life.

On page 224 of this issue, for example, is an urgent appeal for engineers under fifty to apply for positions in the United States Navy. The Navy needs engineers. Most mechanical engineers are already fruitfully engaged in some type of work that is essential to the winning of the war. The few that are not yet so engaged still have an opportunity to offer their services to their country in its time of need.

Geared for War and Peace

OCCASIONAL references in these columns to the work of the A.S.M.E. Boiler Code Committee have called attention to the value and significance of its work and to the quality of service the Society receives from the members of the committee.

The war has brought special and urgent problems to the committee for solution. In the handling of these problems it has been demonstrated that the procedure under which the committee operates and the frequency with which its members convene for carrying on their duties have been exceptionally well adapted to wartime conditions. Under present-day circumstances the committee must act quickly but with wisdom and discretion. It is probable that no group of experts assembled in an emergency could act with the dispatch that the Boiler Code Committee has been able to act and still retain the confidence of the profession. Members of the Committee, who represent those who build, operate, and insure pressure vessels, have traditions of successful accomplishment based on intelligent compromise of the points of view to be considered in their decisions and a confidence in one another as a result of long association. The engineering profession and the public have confidence in the Committee.

The demands of wartime conditions have brought many problems to the Boiler Code Committee that have been handled quickly and satisfactorily. A brief account of the more important actions taken during the last year and a half will be found on page 218 of this issue.

Faithful Workers

DEATH has recently claimed two former chairmen of the A.S.M.E. Committee on Professional Divisions, Harte Cooke, on December 13, and George B. Karelitz on January 19.

Mr. Cooke was widely known by members of the Society. He served long and faithfully on many of its committees. His calm manner, good humor, and unfailing common sense were invaluable assets to committee work. One always marveled at his seemingly tireless energy. On days that his committee met he showed up early and looked in on the staff with that informal friendliness that endeared him to everyone. He stayed late, and when others were going off to bed he was getting into his car to drive across the state in order to be at his own work on the following morning. Almost regardless of where the Society might hold its national meeting, he would be among the first arrivals. Wherever young men were present he would be among them. As head of the Old Guard, that organization of members exempt from payment of dues because of 35 or more years of membership, student members were his particular concern. He sat with them at table and by contact with him they learned about the character and work of engineers. He was an example of the man who gets a lot out of a society because he puts a lot of himself into it.

George Karelitz was a younger man. His death interrupted in full course a career that was useful and brilliant. When conditions in his native Russia made it necessary for him to leave, the United States benefited by offering him an opportunity for the exercise of his talents. He was one of a distinguished group which brought new ideas and old-world training into engineering practice in the new world. An extensive industrial experience matured him for a position at Columbia where his native talent as a teacher brought credit to the institution. He was one of the group that raised the A.S.M.E. Applied Mechanics Division to a position of international importance in engineering. With diligence and thoroughness he tackled the work of the Committee on Professional Divisions, devoting to it long hours of service ungrudgingly given out of his busy career. When he came to the headquarters he did his work in the general offices; he went where the work was done and sat alongside the people who were doing it. Members of the staff came to think of him as one of themselves. Their respect and affection for him were genuine. He was stricken in the service of his adopted country at the time of her sorest need. His health prevented his taking a commission but his loyalty compelled him to make himself available to the nation as a civilian. The extent of that contribution was the sacrifice of his life.

A.S.M.E. Committees

HOW extensive the activities and interests of The American Society of Mechanical Engineers have become is impressively revealed by the list of its committees and their personnel which is published annually as Part 1 of the Society Records—a section of A.S.M.E. Transactions issued every February. The 1943 list has just been sent out. This provides all members and committees with the names of those who will conduct the Society's business during 1943.

A statistically minded person can figure out how great a percentage of members are connected in an official capacity with the administration of the Society's affairs. The average person will content himself with thumbing over the fifty-odd pages of the lists. Here is evidence that no one person and no small group of persons are in control. From the officers and Council members down through the hundreds of committees, names of engineers in all sections of the nation and in a variety of positions and professional areas are represented. Furthermore, in many cases the dates used with many names are evidence that these names are continually changing from year to year as new ones are added and old ones disappear or reappear in different assignments. With but few exceptions all business of the Society is done by these committees. This is a practicable way in which the Society assures itself of government by a democratic process adjusted to the conditions which learned societies have to face. So long as this procedure is maintained the Society will remain a progressive and dynamic institution.

A little thought on what is represented in the services of the men whose names appear in the rosters of committees will convince the average member of the extent of the personal sacrifice that their fellows are making for their Society, for their profession, and for their fellow citizens. It would be fruitless and impossible to estimate the money value of these services or even to compute the man-hours of effort that they represent. Some committees meet regularly at frequent intervals, others once or twice a year, and a few only when some particular piece of business has to be transacted, yet all are always ready to serve and to serve voluntarily without financial compensation even for their out-of-pocket expenses. Many are subject to criticism because they must make decisions which can never meet with universal approval, but all are entitled to much more credit and thanks than they generally receive. They are the backbone of the Society. Without them the Secretary's staff would be able to accomplish little, and vigor and new ideas would disappear from the Society.

Another impressive feature of the committee list is the large number of representatives of the Society on projects in which other societies are jointly engaged. Here is evidence that the A.S.M.E. maintains contacts with other organizations engaged in related activities, thus contributing to the common front which engineering societies offer to the world in cases where more than one of them is involved. Many disappointments have been faced by engineers who have worked for an engineering profession with unified objectives, an effective over-all organization and an authoritative voice to speak on behalf of all engineers and all societies. Honest differences of opinion as to the value of such a setup exist and some attempts to attain a degree of unification have met with frustration while, in restricted areas, others have been reasonably successful. In the absence of an over-all co-ordinating body the avenues of understanding and co-operations afforded by the joint activities in which the A.S.M.E. is officially represented serve an immediate and useful purpose.

Appointments to A.S.M.E. committees is the responsibility of the president, with advice and confirmation coming from the Council. Mr. Coes has rightly looked upon this responsibility as being vitally important, as indeed it is, for the quality of the Society's services is determined by the quality of the men who represent their fellow members on A.S.M.E. Committees.

North of the Border

THE annual meeting of The Engineering Institute of Canada at Toronto, February 11–13, afforded evidence of the immaterial nature of the border between two great nations over which ideas and men of good will travel freely. Closely allied by a common heritage of institutions based on peace and personal freedom and united more solidly than ever before in the prosecution of a common task, engineers on both sides of the Canadian border mingle and understand one another as though they were citizens of a common country.

There was evidence also of tremendous industrial progress which the war has accelerated. An exhibit of war production demonstrated the variety and extent of Canadian talent. Of special interest were examples of the most modern techniques of building airplanes of wood. The rapid rise of the shipbuilding industry was described in an illustrated luncheon address. But most astounding of all were the beautiful examples of precision workmanship in the field of optical instruments, an entirely new industry for Canada. Interest in postwar conditions was keen, and it is evident that Canada means to take a prominent place in the engineering industries.

POSTWAR INDUSTRIAL DEVELOPMENT

By GEORGE A. SLOAN

NEW YORK, N. Y.

WHEN peace comes, this country will undoubtedly face the greatest transformation in its history—the transfer of war production, of labor, machinery, and plants to the production of goods to fill the pent-up peacetime demand—the transition to peace with as little sacrifice as possible of income and employment.

The long-time changes in industrial allocation upon which the war-production program has been superimposed presents a series of highly complicated problems. Many communities, now largely dependent upon military establishments, will feel the immediate effects of this transfer to peace economy.

In this great transition period our business executives and engineers and scientists and research laboratories will undoubtedly face the biggest opportunity and the biggest responsibility of our generation, if we are to maintain a much desired high level of productive employment in the postwar era.

Obviously, the getting on with this war job is the first concern and obligation of all of us. The big job today is to annihilate Schicklegruber, the Third Reich, and the fanatical little militarists in the Pacific. At the same time it is up to industry to be laying plans now for the years to come so that we will be ready to make the fullest possible postwar contribution to business and employment stability.

It is comforting to know that many corporations in some of our major industries, now converted in whole or in substantial part to war production, have set up departments to which they have assigned engineers, research men, and manufacturing and merchandising specialists to plan to meet postwar conditions.

Let me tell you what a few of these industries are doing and in some cases what estimates they are now making for the future.

AUTOMOBILE INDUSTRY

For the period immediately following the war, the tooling for the 1942 models, which was set aside for the duration by the automobile manufacturers, will undoubtedly be put to work, and those of you who are obliged to have a new car fairly promptly will probably be given an opportunity to buy a 1942 Ford, Plymouth, Pontiac, Studebaker, Chevrolet, or some other similar type weighing approximately 3000 pounds. But give these automobile manufacturers, who are now performing miracles in war production, a relatively few months' time to retool and to otherwise adapt themselves to the new consumer demands and you will probably see these same plants turning out a 2000-pound car made of lightweight metal with an aviation motor energized by 100-octane gasoline which will provide twice the mileage that we have known in the recent past. Here will be a revolutionary type of transportation which may well result in an increase in the production and use of automobiles as great as that occurring after the last war.

In November, 1918, there were 5,600,000 passenger automobiles in the United States. Today there are 30 million, including those jacked up like my own. At the close of the last war the automobile industry predicated a total of 15 million passenger cars, stopping at that figure no doubt because of the fear of too much road congestion! What happened? When the urge was strong enough new roads were built, which in turn provided more jobs in road construction and, more especially, in low-cost suburban housing. New and better highways were constructed for twice as many cars as the most optimistic public-relations counsel of the automobile industry had foreseen. Who can say what demand there will be in the years to come for a better, lighter, and less expensive motor vehicle?

RUBBER TIRES

In 1941 there were 220,000 long tons of rubber used in the manufacture of 45 million automobile tires. Thirty thousand people each month were employed in their manufacture. These tires sold for 520 million dollars. When you consider the backlog of demand that this war is creating there is no reason why that figure should not be increased 50 per cent annually over the ten-year period following the conclusion of this war.

The best minds in the truck and rubber industry have for years prophesied the day would come when the tonnage of rubber used in truck tires would be greater than in automobile tires. It took a war to bring this about. But it has happened. In 1942 there were 7000 long tons of rubber used in the manufacture of automobile tires in the United States and 200,000 long tons of rubber used in the manufacture of truck tires.

After the last war the pneumatic tire and air brakes were just coming into use. We then had 525,000 short-haul trucks and no long-distance trucks. Today there are five million trucks in use in the United States. With the great expansion of truck highways that will inevitably be constructed in the ten years after this war, you can jot down a ten-million-truck figure for that period and not be outside the bounds of a conservative estimate. There are hundreds of other uses of rubber that merely await the lifting of the curtain of war.

Whether synthetic rubber will replace the natural latex is not likely to make much difference in the ultimate volume of the fabricated materials in the United States. Whichever is the most economical and the most valuable will prevail in the end. In the opinion of the leaders in the industry, tremendous quantities of both synthetic and natural rubber will be consumed in the postwar years. And of course, while there is some tough fighting ahead, it will only be a matter of time until the Japanese will be driven out of the Malay Peninsula and the rest of that part of the Far East from whence comes 90 per cent of the world's rubber supply.

There is no secret or mystery attendant upon the delay in synthetic production. It so happens that the same type of plant is required for the manufacture of 100-octane gas as for butadiene. The need for both is great, but the immediate need for aviation gas is greater. So Old Man Priorities says it will be gas for aviation until we reach a point—soon, let us hope—when we can step on both the gas and the butadiene.

From an address at the Annual H-Y-P Huddle of the Harvard Engineering Society, the Yale Engineering Association, and the Princeton Engineering Association, at the Yale Club of New York City, January 22, 1943.

COTTON TEXTILES

I have made some recent inquiries about cotton textiles, because of my long association with that industry, because it is one of the major manufacturing groups in America, and because of the very different position that it will occupy at the conclusion of this war as compared with the last.

You may recall that for many years after the last war cotton textiles came to be regarded as a historic example of potential overproduction. The truth is that the problem all through the 20's and 30's was not one of overproduction, but rather one of right production according to the needs of the public. Mr. Samuel Crowther, the distinguished author and economist, once said, "Any production that goes forward without recognizing the requirements of the consumer is not properly to be regarded as production at all but as an adventure in spending money foolishly." That is something for some of our "super" intellectuals to remember after this war, before they begin their demands for production and still more production, else an inevitable surplus of some of these products, whether tallyhos or bird cages, will present a problem for the psychiatrist, rather than for the engineer.

The cotton-textile industry came out of the 1914–1918 world conflict as a war casualty of considerable magnitude. Its convalescent period covered the greater part of two decades. Built as a single-shift industry, it rapidly went to two shifts during the last war under the pressure of military demands, and it ended with a few mills running three shifts, or twenty-four hours daily. I lived close to the resultant chaos and I am happy for the more than one thousand cotton mills of today and their half-million employees that a long period of adversity finally demonstrated the futility of depending upon speculative profit in raw cotton rather than manufacturing margin.

In 1919, at the conclusion of the last war, there were 35 million cotton spindles in the United States. In 1942, there were only 23,800,000 spindles in the United States.

In the postwar years of the 20's there was great irregularity in the running time of the cotton-textile mills. In 1942, and indeed since 1933, the industry has observed a maximum work week of forty hours. A multiplicity of independent organizations still characterizes practically all the numerous divisions of the industry. But there is today a much higher degree of stabilization than at any time during the past quarter of a century. It augurs well for the postwar period—if only my old friends in the cotton-textile industry have learned the lesson of experience sufficiently to restrain themselves from three-shift production in the face of a two-shift demand.

It is readily recognized that developments in other fields will make inroads on cotton. There are the improved high-tenacity rayons, which are already recognized for use in tires; also nylons, vinyons, and other new synthetics, glass fibers, and purified and stronger paper.

Probably the most important step to insure that cotton holds its place in the postwar era is the research-mindedness that has spread through the industry during the past decade and the recent expansion of research facilities. The largest cotton mills have installed research departments staffed by scientists, many distinguished in their particular fields. Cotton manufacturers in North Carolina have subscribed a fund of one-half million dollars to supplement the mechanical engineering in cotton manufacturing carried on by their principal textile school. The Cotton-Textile Institute now employs scientists who are actively engaged in promoting research. The United States Department of Agriculture has recently completed a laboratory in New Orleans where cotton research will be one of its principal assignments. The National Cotton Council, of Memphis, Tenn., also has a research department in connection with the Mellon Institute.

There are numerous war uses of cotton which suggest postwar employment. The Army is buying a cotton container for food to be used by mountain and jungle troops and for clothing bags; they are specially waterproofed and keep the soldiers' clothing and food dry under all weather conditions. Pigmented and plasticized synthetic resins are used to give cotton cloth the requisite properties. Other treated cotton fabrics form an important part of the new one-man parachute boats, instantly inflatable, and bomber gas tanks are made of leak-proof cotton.

The engineering and research work put into these developments will fortify the cotton-textile industry and the cotton farmers in the years to come. The postwar goal of cotton manufacturers, as in the case of so many other industries, is widening markets with lower cost of production.

THE FOOD INDUSTRY

Without attempting to cover the planning and research activities of the individual food manufacturers in anticipation of the new tastes and enlarged appetites of the postwar period, I do wish to tell you of a most important industry-wide development in the food industry during the year just passed.

The Nutrition Foundation, formed in January, 1942, by a cross section of leading food and related manufacturers, has today a five-year endowment fund of $1,100,000 with considerably more in anticipation.

The major objective of the Nutrition Foundation is the improvement of public health by a broad investigation of the food supply of the nation—its chemical, biological, and physical properties. It approaches this task through extension of knowledge concerning nutrition. The principles established will automatically serve as a scientific guide to industry.

Up to now, the burden of supporting research in educational institutions has been carried either by endowments or by public funds. Endowment funds for the future may well be expected to decrease; there will be far fewer persons of sufficient means to leave money to medical schools and universities which contribute to research developments in the nutritional field, and the return on present capital funds is diminishing. If the freedom of research is to be maintained, a substantial part of the burden of its financial support must be assumed by industry.

Unless research is kept free and independent, our scientific laboratories and educational centers may come under ever-increasing political control. That, in my opinion, would be extremely unfortunate for the people of America. Need I remind you that the great advances of mankind have come out of the efforts of free men?

Another aspect of the Foundation's program is the training of young people for positions of leadership in the food industry as well as in pure research, in the years to come.

In 1942, fifty-four grants totaling $168,000 were made by the Nutrition Foundation to 36 universities in various parts of the United States. These grants are used largely to provide research fellowships for outstanding graduate and postdoctorate students.

Specific studies which will have the attention of the Nutrition Foundation during the coming year include more effective feeding of the armed forces and continued attention to diet and nutrition for workers in our war industries. On the home front, our research advisers are watching the food supply of the civilian population, with particular attention to the nutritional requirements of mothers and infants.

In the recent establishment of this foundation, the food industry has made an earnest effort to aid in the solution of problems which have arisen in the midst of a war emergency. It has done more than this. It has acknowledged a definite social responsibility and function in making further explorations into the science of nutrition for the betterment of mankind.

In these days, when America is deepening her sense of postwar leadership, we feel that her contributions to the world's knowledge of nutrition, as a first step toward better health, will be recognized as fundamental.

BUILDING INDUSTRY

In the two years between 1940 and July, 1942, there were government appropriations of 12 billion dollars and private-enterprise appropriations of 3 billion dollars, or a total of 15 billion, for the sole purpose of enlarging existing plants and building new production units. We have been building 8 billion dollars' worth of new factories, adding 25 per cent to our industrial capacity, in order to produce 20 billion dollars worth of goods. The question arises as to how many of these plants will be needed for peacetime production. In many instances it may be assumed that our new war factories are better equipped to meet future needs for peacetime demands than older plants. Undoubtedly, competition will force alterations and abandonment of less efficient plants and buildings. This and the already growing problem of a shift in population plus the already large backlog in housing will cause a tremendous expansion of residential building in many parts of the United States. Some experts anticipate a market of 800,000 or more dwellings in the first year of the postwar period. Others envisage a postwar market absorbing this number of new dwellings annually for the decade after the war, with the country still in need of a huge volume of repairs. Since it is estimated that of the 40 million homes in the United States one third are more than fifty years old, it is quite obvious that our housing possibilities are almost unlimited. New communities will have to be built with their associated necessities, such as hospitals and schools, improved transportation facilities, highways, bridges, terminals, and the like.

With the coming of peace, research will be ready with thousands of new building products. Many new industries will be developed. Vast changes in construction methods and building materials and equipment are now under way. Synthetic materials are stimulating experiment for improvement.

One of the conspicuous results of war research and construction is the advancing technique of prefabrication. Entire towns have been built as a single construction. Since the great mass market for housing will be in the low-cost field, the postwar prefabricated production is bound to be felt substantially in the home-building industry. Already there are under development streamline factories running off an assembly line five-, six-, and seven-room houses in 45 to 50 minutes! Obviously, this will bring dislocations, as always happens with economic improvement through fundamentally changed methods. But the cumulative beneficial effects to small equipment manufacturers and to small erection crews in particular will mean greater improvement and work for employees under more satisfactory conditions.

THE GOVERNMENT'S ATTITUDE

The inevitable consequences of our effective participation in total war are burdensome taxation and unprecedented governmental control of the economy. None of us questions the necessity for a full mobilization of our material as well as our human resources, but all of us retain a voice in deciding upon the methods to be employed. Taxation should cover the largest possible proportion of the costs of the war, and the inflationary process of selling bonds to the commercial banks should be used only to the extent that it is absolutely necessary. In taxation, our guiding principle should be universal participation and equality of sacrifice. For individuals this means a broadly based, graduated income tax on current income and taxes on consumption paid by every citizen in accordance with the means at his or her disposal. Here we should stress certainty of collection by the government and a minimum of uncertainty for the taxpayer in determining his obligations. Income taxes on corporations should be designed to raise the largest possible revenue, but care should be exercised to leave an incentive for plant improvement and expansion in production. Sound economic principles should not be subordinated to political expediency and every effort should be made by the government to eliminate expenditures which are not essential to national security.

Along with the burden of taxation, we cheerfully accept a rationed economy and price control as wartime measures. When peace is restored, however, we must return once more to a civilian economy. We must insist on, first, the relaxation, and then the complete elimination, of such controls. While our industrial plant is being reconverted to the production of civilian goods, there will be scarcities of many goods for which the pent-up demand will be great. At that time price controls may be necessary to prevent a skyrocketing of prices which could lead to a serious reaction. However, once our plant and equipment are again engaged in the production of civilian goods, there can be no basis for the retention of governmental restrictions on materials or prices. There must be no compromising on this issue if we are to reopen the road to freedom. Our objective should be to complete the transition to a free society as quickly as possible. In too many parts of the world we find today a centralized controlled economy, where the people have traded their liberty for well-turned phrases and promises.

When the war ends, we shall have an expanded and modernized industrial plant manned by an enlarged, skilled labor force under the direction of men fresh from performing the miracles of war production. All of the elements will be present, therefore, for our entrance into a period of sustained prosperity. In order to achieve a high level of production and employment, however, we will need a vigorously expanding private enterprise.

To clear the way our government must provide a proper environment for the risk-taking required in the development of the new products and processes which science and research have made available. For a time it may be necessary to continue graduated taxes on individual incomes at high rates. But there need be no delay in repealing the corporate excess-profits tax and the tax on capital gains.

In addition to the adoption of a system of taxation which will not discourage or discriminate against business, the government can do much to stimulate the expansion of industry and commerce and the confidence of private investors. Public works are a useful means of providing public services which the people desire, but they should not be used to subsidize competition with private undustry. The regulation of corporate practices should be made effective by the certain processes of law and not by the arbitrary rulings of commissions and administrators. There must be a proper and workable respect for civil and property rights and for contractual obligations. The part of government, therefore, should be to act as an impartial umpire and adviser to all groups.

CONCLUSION

Given the proper atmosphere in which to function, industry can and will solve this postwar problem. I have this conviction because of my confidence in the resources, courage, and ability of our industrial management. It is in such business and engineering groups, as we have represented here tonight, that we shall find that leadership necessary to promote sound national thinking and to maintain and strengthen our American system.

100,000-HOUR CREEP TEST

By ERNEST L. ROBINSON

TURBINE ENGINEERING DEPARTMENT, GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

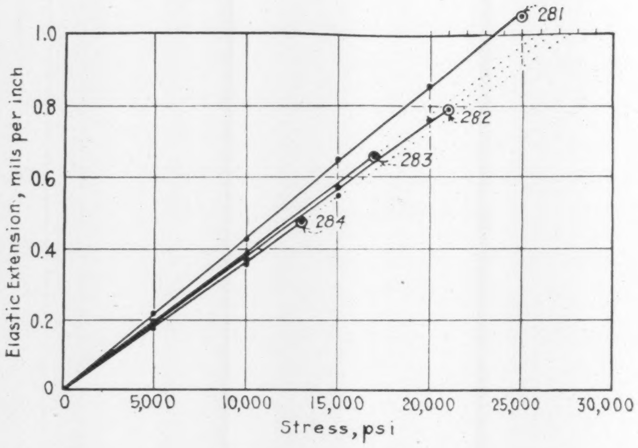
On Oct. 8, 1942, a series of 100,000-hour creep tests was completed by the General Electric Company on four bars of S.A.E. 4330 type nickel-chrome-molybdenum steel. These tests were started on March 27, 1931, and the bars had been continuously at a temperature of 842 F (450 C) throughout the test period except for a brief period in the summer of 1935, when after 37,000 hours the furnace was shut down and moved to another building.

Because these tests are the first long-time high-temperature creep tests actually to attain the full time of 100,000 hours, the bare results without discussion are being made immediately available to American industry in order that builders of high-temperature equipment may have such guidance as is thereby afforded to the extrapolation of briefer tests.

Elastic extensions are shown separately in Fig. 1. These lines serve to determine the elastic modulus for each of the several bars. These values were well defined since, because the furnace was moved in 1935, each bar was loaded and unloaded twice. It did not seem possible to represent the elastic behavior of all four bars by a single value of the modulus.

Fig. 2 presents the curves of increasing plastic extension throughout the entire interval.

Table 1 lists the chemical composition, heat-treatment, and physical properties at room temperature.



Elastic Modulus at 842 F

281: 23,500,000 psi
282: 26,600,000 psi
283: 25,900,000 psi
284: 27,600,000 psi

FIG. 1 ELASTIC EXTENSIONS IMMEDIATELY RECOVERABLE ON REMOVAL OF LOAD

(Because the furnace was shut down and moved at 37,000 hours, each bar was loaded and unloaded twice, giving four separate measurements of the modulus of elasticity for each bar.)

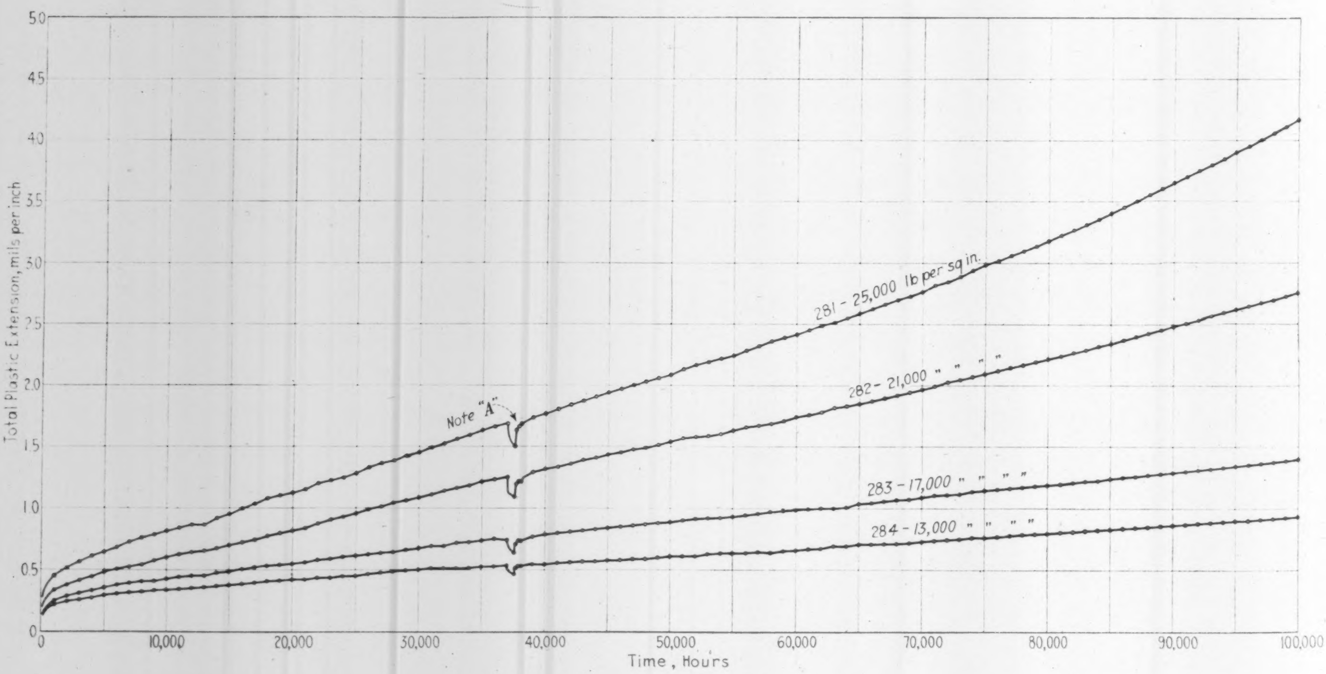


FIG. 2 CURVES OF TOTAL PLASTIC EXTENSION THROUGHOUT THE 100,000 HOURS AT 842 F. (ELASTIC EXTENSION IS NOT INCLUDED. SEE FIG. 1)

(Note A: After 37,000 hours, the loads were dropped to 1000 psi for a period of 570 hours after which the furnace was shut down, moved to a different building, and started once more. These curves show plastic recovery only.)

TABLE 1

Description of: S.A.E. Type 4330 Steel.

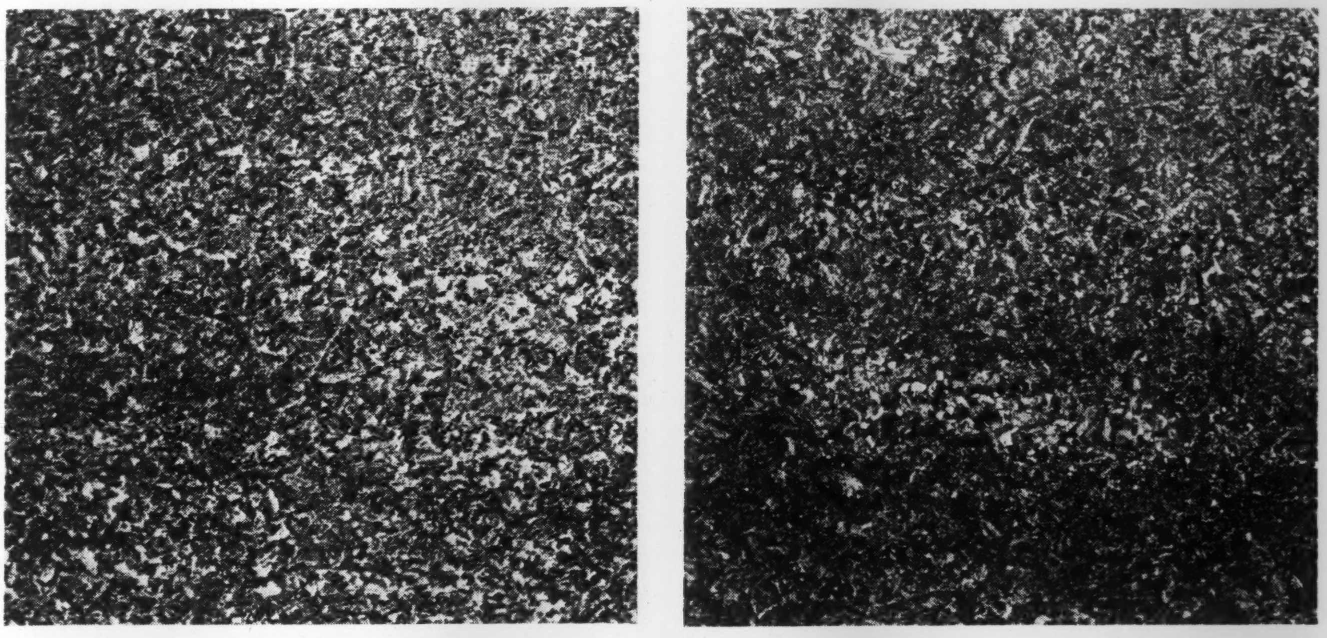
Chemical composition, per cent: 0.31 C, 2.05 Ni, 0.83 Cr, 0.45 Mo, 0.54 Mn, 0.11 Si.

Heat-treatment: 1517 F (825 C) furnace cool, 1247 F (675 C) oil quench, 797 F (425 C) furnace cool.

Physical properties: Tensile strength 111,800 psi; elastic limit 83,000 psi; elongation 22.5 per cent; reduction of area 59.5 per cent.

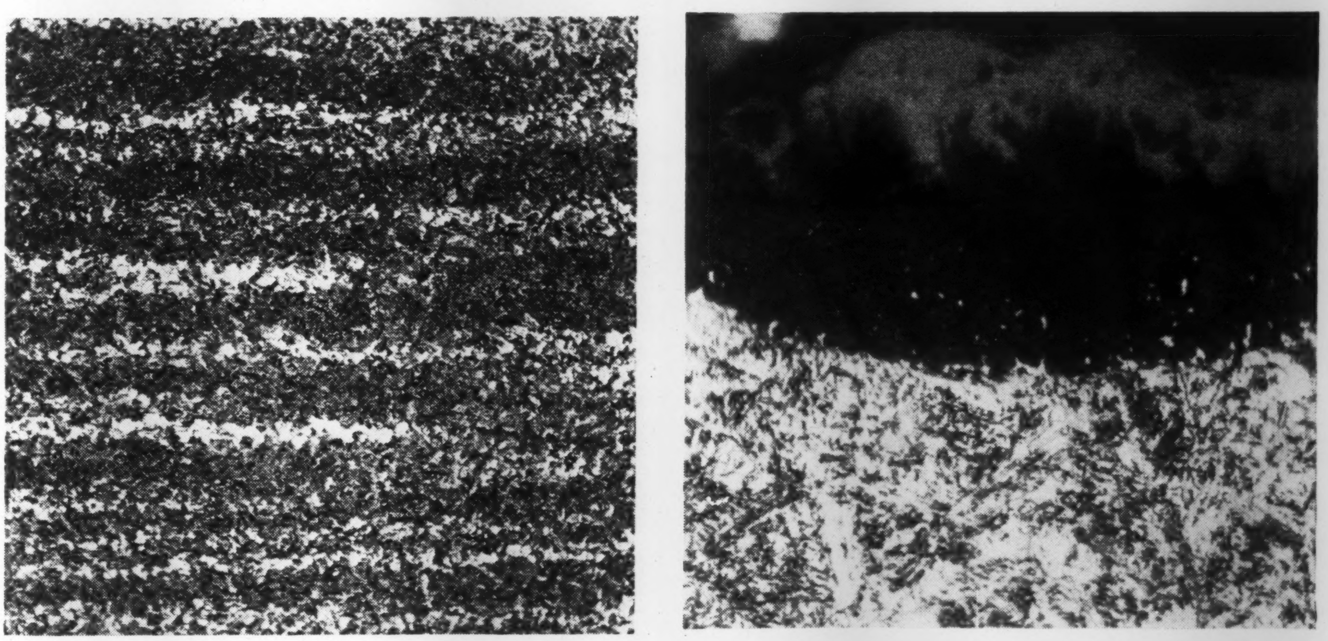
Fig. 3 shows photomicrographs of the material, *A*, in its original condition, and *B* and *C* for the two most highly stressed bars after the 100,000-hour period at high temperature. All these bars came from the same heat of steel.

Fig. 3*D* shows the oxide film magnified 1000 times at the conclusion of the test. The ends of this bar which had not been subjected to high temperature had a diameter of 0.5049 in. The part of the bar in the furnace measured 0.5075 in. diameter over the oxide film and 0.5032 with the film removed down to bright metal. Surface penetration thus amounted to less than 1 mil in 100,000 hours.



A Original condition (magnified 100 diam)

B Item 281 after 100,000 hours at 842 F under 25,000 psi (magnified 100 diam)



C Item 282 after 100,000 hours at 842 F under 21,000 psi (magnified 100 diam)

D Oxide film on surface of Item 282 after 100,000 hours at 842 F under 21,000 psi (magnified 1000 diam)

FIG. 3 PHOTOMICROGRAPHS OF THE MATERIAL

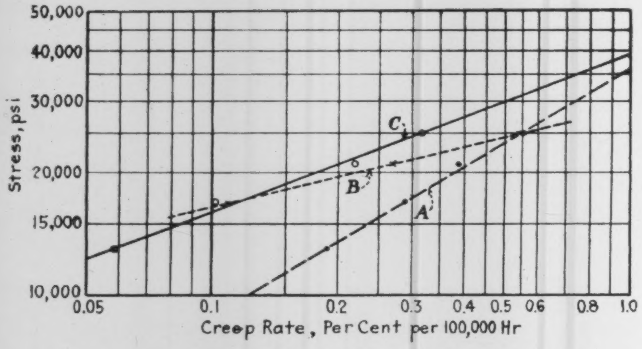


FIG. 4 CREEP RATES AT 842 F

Line *A*: After first 2000 hours
Line *B*: Final rate after 100,000 hours
Line *C*: Minimum rate during entire 100,000 hours. This line also represents the rate with a total elastic-plus-plastic extension of 2 mils per inch.

Fig. 4 shows several relations between stress and creep rate. It may be noted that the bar under 25,000 psi finished the 100,000-hour test with practically the same creep rate it had at 2000 hours. However, during a number of the intervening years it had elongated at a rate but little more than half as fast. On the other hand, the bar under 17,000 psi finished the test with its minimum rate, and Fig. 4 would suggest that the bar under 13,000 psi had not yet attained its minimum creep rate.

Since these are all constant-stress tests an estimate of probable performance under relaxation conditions with an elastic-plus-plastic extension of 2 mils per inch may be made by noting the creep rate on each curve in Fig. 2 at a plastic extension less than 2 mils per inch by the amount of the elastic extension shown in Fig. 1. This procedure leads to a point on each curve in the region of minimum rates and thus gives a line in Fig. 4 coinciding with line *C* for minimum rates.

The first four years of these tests were described in a paper by S. H. Weaver entitled, "The Creep Curve and Stability of Steels at Constant Stress and Temperature," Trans. A.S.M.E., vol. 58, November, 1936, pp. 745–751.

A series of 10,000-hour tests on closely similar material which proved to have little more than a quarter the creep strength was described in an article by P. H. Clark and E. L. Robinson entitled "An Automatic Creep Test Furnace," *Metals and Alloys*, February, 1935.

The wide variation in measured creep strength of various samples of this type of material was discussed by L. L. Wyman in an article entitled "The Creep of Steels as Influenced by Microstructure," MECHANICAL ENGINEERING, October, 1935, pp. 625–627, discussed in a letter to the editor, MECHANICAL ENGINEERING, March, 1936, p. 194. The strong material of the 100,000-hour test series was identified as steel "C" in Wyman's article, while the weak material of the 10,000-hour test series described by Clark and Robinson in *Metals and Alloys* was called steel "E" by Wyman.

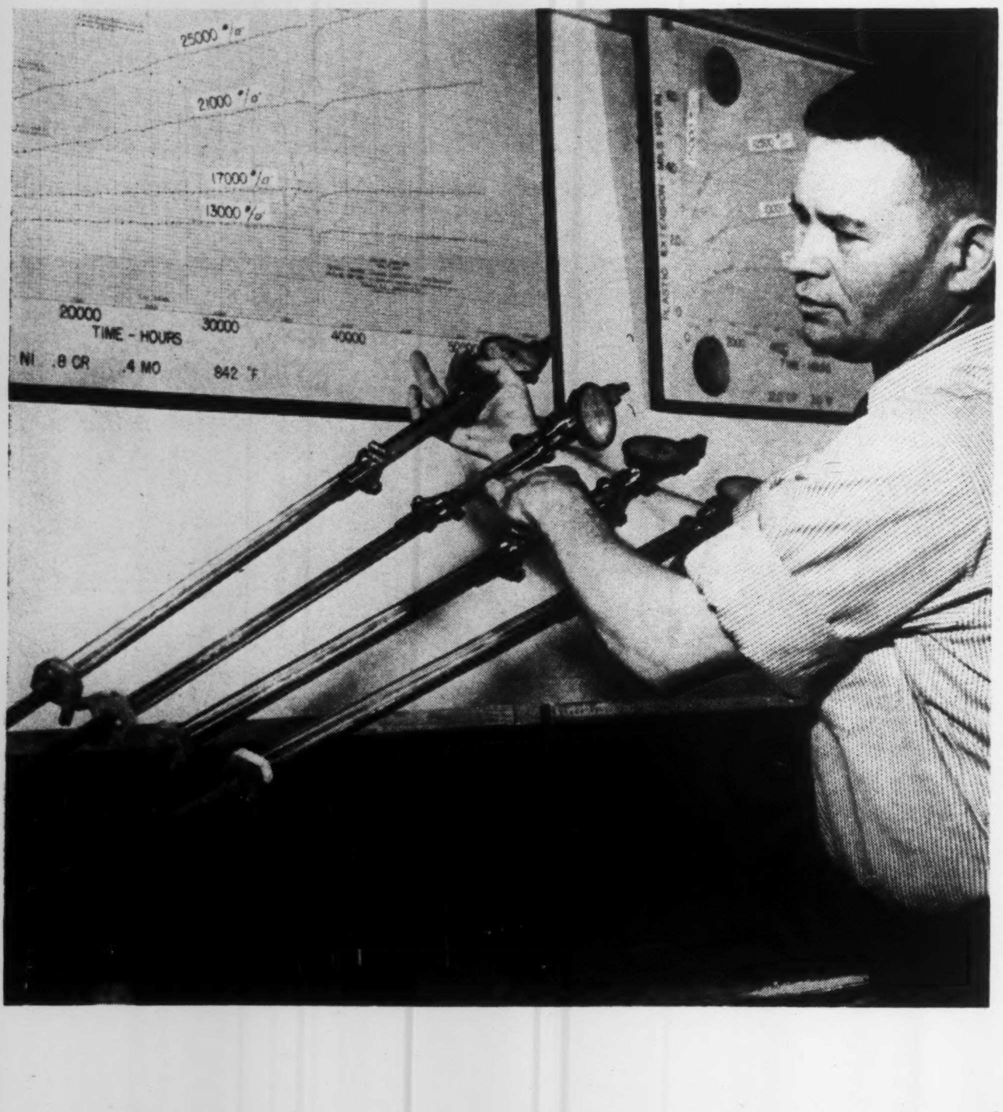


FIG. 5 THE FOUR TEST RODS THAT UNDERWENT THE 100,000-HOUR TEST

(Chart on wall behind them carries a record of the first 50,000 hours.)

Problems in AIRCRAFT STRUCTURAL RESEARCH

By F. R. SHANLEY

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IN so far as it is possible under wartime restrictions, the purpose of this paper is to present a comprehensive picture of the more important problems in aircraft structural design and research in the interest of advancing the knowledge of those engaged in industries, which formerly had but slight connection with aeronautical engineering, but today are deeply involved in various phases of aircraft work. A similar objective was stated by Dr. A. G. Pugsley (1)[1] as follows:

> ". . . By a discussion of the general engineering principles behind the structural work of aeronautics it is hoped at once to help newcomers to appreciate the present complicated position and the breadth of current problems and to stimulate more experienced workers to the further clarification of the principles and problems involved."

It will obviously be impossible to discuss any of the problems in great detail and the treatment must therefore remain somewhat untechnical; furthermore, lack of time has made it impossible to compile a complete list of references on the various subjects covered. Such references, however, are readily available through the publications of the National Advisory Committee for Aeronautics (N.A.C.A.), the Institute of the Aeronautical Sciences, and various technical journals. Occasional references have been included, however, as a guide for those interested in obtaining additional information.

OBJECTS OF AIRCRAFT STRUCTURAL RESEARCH

First, let us ask ourselves why we spend time and money on structural research. The main reasons seem to be as follows:

1 To eliminate structural failures.
2 To reduce the weight of the structure.
3 To reduce design time.
4 To reduce fabrication time (and cost).
5 To improve the service and maintenance characteristics of the airplane.

The first of these objectives is, of course, so obvious that it should be taken for granted. In fact, items 1 and 2 should actually be combined under the customary term "strength/weight," as there would be no danger of structural failure if the designer were allowed to use an unlimited amount of weight. The real object of research on the strength of the airplane is, therefore, weight reduction, and the results must finally be evaluated by this yardstick, not by strength alone.

Item 3, the reduction of design time, is particularly important at the present moment. Every airplane designer tends to regard the stress department as a potential "bottleneck." Too often this potential "bottleneck" turns out to be a real one, due to the complexity of the stress analysis for a modern structure, or because of the failure to estimate with sufficient accuracy the correct size of the structural members. Anything that can be done to speed up the structural analysis and to make it more reliable will have an important effect in reducing the time required to release the drawings.

Item 4, reduction of fabrication time, is also extremely important under war conditions. A reduction of cost will usually follow as a consequence of the reduction of time. Much can be done by the designer to assist the manufacturing departments in speeding up their production. The modern philosophy of design or production is to consider the final manufacturing problems from the very beginning of the design.

Item 5, service and maintenance, has received too little attention in the past. More accurately, this phase of design has not been suitably correlated with other phases and has usually had to be taken care of after the airplane has been put in service. The ideal research and development program will consider all of these items and will give them proper weight from the beginning.

CLASSIFICATION OF STRUCTURAL RESEARCH PROBLEMS

Having classified the objectives toward which structural research should be aimed, it is now advisable to subdivide the research problems themselves on some suitable basis. From the strength/weight standpoint, the most logical breakdown appears to be that of external, internal, and allowable loads. (To this should be added a fourth division, which might be called fabrication.) Table 1 shows how these subjects are further broken down for greater convenience. Before taking up

TABLE 1 CLASSIFICATION OF STRUCTURAL SUBJECTS

1 External Loads:
- (*a*) Flight
  - Maneuvering
  - Gusts
  - Control surfaces
  - Engine
- (*b*) Ground (or water)
  - Landing
  - Taxiing
  - Handling (towing)
- (*c*) Miscellaneous
  - Local (inertia) loads
  - Controls (pilot)
  - Pressure(cabin, hydraulic, etc.)
  - Rigging and service
  - Flutter
  - Compressibility effects

3 Allowable (Failing) Loads:
- (*a*) Buckling (instability)
  - Columns
  - Panels
  - Effective width
  - End fixity
  - Edge restraint
  - Shear beams
  - General instability
- (*b*) Failure of materials
  - Combined loads
  - Interaction curves
  - Stress concentration
  - Fatigue
  - Impact
  - Joints
  - Structural indexes
  - Material properties

2 Internal Loads:
(Stress distribution)
- (*a*) Frameworks
  - Trusses
  - Space frameworks
  - Rings
  - Relaxation methods
- (*b*) Beams
  - Solid type
  - Box Beams
  - Shear lag
  - Unit method
  - Torsion
  - Cutouts

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[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

Contributed by the Aeronautic Division and presented at the Annual Meeting, New York, N. Y., Nov. 30–Dec. 4, 1942, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

specific problems it is advisable to discuss the relationship which exists between these different classes of structural research.

Considering the three subdivisions shown in Table 1, we probably know less about external loads than any other phase of airplane design. This condition will, no doubt, always exist, as it is impossible to determine exactly the loads which will act on a certain airplane. However, it is possible to obtain statistics on the most probable loads that will be imposed on a *type* of airplane, which information is extremely valuable when dealing with the problem as a whole.

Much confusion and wasted effort have resulted from lack of understanding and application of this important principle, the principle of probability. Once we realize that the design of the structure starts out on a probability basis, we can guide ourselves accordingly in dealing with other phases of the problem which are more susceptible to exact analysis.

Thus, the first suggestion to be offered for future research is a comprehensive study of the probable errors or deviations entering into the design and fabrication of an airplane structure. To make such a study, it would be necessary to know or to estimate the probable errors or deviations for such things as load factors, mathematical calculations, material properties, manufacturing tolerances, and all the other factors which have any appreciable effect on the final result.

At first sight this is a formidable task, but actually it would not be necessary to know the probable errors to any great degree of accuracy. The greatest benefit to be derived from such a study is that it would show up the weak links of the chain and would thereby serve as an excellent guide for future research and development work.

Keeping in mind the ultimate yardstick of weight reduction, the suggested study could be expanded to include estimates of the weight involved for each factor, that is, the weight that would have to be added to reduce the particular probable error to zero or some arbitrarily small value. This would reveal cases in which a small amount of additional weight would more than compensate for a lack of accurate data, for shortcut methods of analysis, for lack of quality control in manufacturing, etc.

The ultimate form of such an investigation would consist of a summation of all possible causes of structural failures, the final result being a certain small probability of failure which is considered to be tolerable. In making this summation, it would, of course, be essential to combine various probabilities in the proper manner. For instance, if a certain failure could result only through simultaneous occurrence of several unfavorable errors or tolerances, the probability of such failures would be much less than in the case where any one error would cause failure independently of the others. A clear understanding and evaluation of these principles is of great importance not only to the designers but particularly to government agencies responsible for the airworthiness requirements and specifications.

A study of this type would, no doubt, reveal most emphatically the relative lack of knowledge or accuracy in the field of external loads, as constrasted with the state of knowledge in the fields of internal loads. In addition to the inherent difficulty of handling this problem on a precise basis, it is true also that less research work has been done in this field than in the others. One obvious reason for this is that the airplane itself is a relatively new development; hence no background on external loads is available from other industries. In the fields of internal and allowable loads, however, and particularly in fabrication, much work has been done outside of the airplane industry and existing methods of attack can often be used directly.

EXTERNAL LOADS

Since this phase of aircraft structural research does not have a direct counterpart in other engineering fields, it will not be taken up in detail in this paper. Furthermore, the problems of external loads are in general well understood by aircraft engineers and by various government research agencies, particularly the N.A.C.A., which has done a great deal of work on the subject. There are, however, a few points which may be of interest to nonaircraft people and upon which the experience of other industries may be beneficial to the airplane designers. One of these pertains to the instruments and methods used in collecting statistical data from which the external loads may be determined. As previously noted, it is practically impossible to calculate accurately the loads to which the airplane will be subjected. A statistical approach to this problem must, therefore, be used.

The best example of what has already been done in this field is the instrument known as the V-g recorder, a description of which is given by R. V. Rhode (2). This instrument was developed by the N.A.C.A. and is now in constant use. The records obtained on various types of airplanes under different flight conditions have furnished a most valuable background for the determination of the flight loading conditions.

The instrument furnishes a plot of maximum acceleration (normal to the wings) against the air speed (dynamic pressure) of the airplane. The combination of these two factors not only enables us to calculate the total load acting on the wings but also gives us a basis for determining the distribution of these loads. The problem of determining flight loads may be considered to be well in hand at this time and therefore will not be discussed in any further detail.

Our greatest need at the present time is for more statistical data on local accelerations or stresses in various parts of the airplane structure, particularly the tail surfaces and the landing gear. It is desirable to know, not only the maximum accelerations or stresses experienced over a long period of time but also the number of times that various values of these factors have been experienced. This type of information is of great value in connection with fatigue conditions, for which relatively little information is available on the airplane.

Although accelerometers have long been used as a method of obtaining such data, it now appears that the best instrument for obtaining local information is the electric strain gage. The technical difficulties in obtaining suitable accelerometers are not the only reasons for this statement, since it should be remembered that acceleration readings alone are of no particular interest, as they must be multiplied by an effective mass before the loads and stresses can be calculated. The problem of determining the proper effective mass often turns out to be more difficult than that of obtaining the local acceleration. The use of the resistance type of electrical strain gage permits us to record the strains at any desired point on the structure. This type of strain gage, which is nothing more than several loops of fine wire pasted to the structure, is described by C. E. Strang (3). The gage is easy to install, takes up very little space, and enables a large number of readings to be made relatively quickly. The ideal solution to the external-load problem would be to have a large number of such gages installed at strategic points on the structure of the airplane and to devise some means of recording statistically the frequency distribution of the strains developed in actual operation of the airplane. Such equipment would have to be relatively inexpensive and foolproof so that it could be installed in a large number of airplanes and left unattended for relatively long periods. This problem is being worked on by the N.A.C.A., Civil Aeronautics Authority (C.A.A.), and other agencies.

The de Forest type of scratch gage (4) is quite useful in obtaining statistical information on the strains developed in the structure, but it has the disadvantage of using up the record in a relatively short time. Some attempts have been made to modify this gage so that it would not operate until after a certain strain had been exceeded. This would eliminate a large portion of the record, in which we are not particularly interested, and would thereby extend the time range much farther. Fig. 1 shows the ordinary scratch gage; other types are available for various purposes.

Dr. Pugsley (1) stated the case very clearly when he said:

". . . A second factor for comment is the part which statistical methods and viewpoints may play in the future. It would seem to behoove research workers to make themselves at home with the ideas of statistical theory, to acquire a detailed knowledge of existing structural statistics, and to interest themselves in the collection of further data."

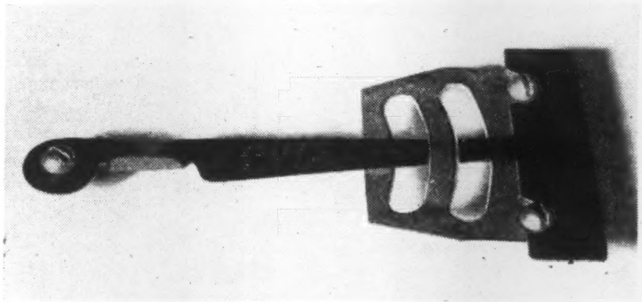

FIG. 1 SCRATCH TYPE OF STRAIN GAGE

Although the greatest need appears to be for additional statistical information, much remains to be done on the mathematical analysis of the airplane as a flexible body subjected to various loading conditions. Most of the work in this field has been done in connection with gusts (5). There have also been some investigations for landing conditions. The greatest need at the moment appears to be for a more complete and rational analysis of the behavior of the airplane under various impact conditions and for taxiing over rough ground. Such a study should include the effects of structural flexibility, shock-absorber characteristics, and aerodynamic effects. Dr. E. G. Keller, consulting engineer for Lockheed Aircraft Corporation, has been working on this problem recently, and the preliminary results of his investigation have proved to be of considerable interest.

These results indicate that the effects of structural flexibility are not of great importance in the case of a hard landing, in which the load is applied over an appreciable interval. On the other hand, in taxiing over rough ground, the forces are applied to the landing gear quite rapidly, and it is entirely possible that the loads developed under such conditions are much greater near the point of contact than at some distance away from this point. There are also indications that, in taxiing over rough ground, the forced oscillation of the tail surfaces may be further built up by aerodynamic effects, which may account for the high values of local acceleration that have been measured at the tail surfaces of actual airplanes. The importance of this particular subject is emphasized by the fact that there have been several cases of failure of tail surfaces under such conditions, particularly for the nose-wheel type of airplane to which most of these remarks apply.

Remembering that weight reduction is the ultimate objective of all structural research, it should be noted that further research along these lines will tend to eliminate weight by telling us how to distribute the structural weight more efficiently. For instance, it is useless to provide a great deal of weight for the main landing gear, if the nose gear is relatively understrength and would always fail first. Our knowledge of nose-gear loads is still far from complete, and this is one of the subjects on which intensive research work should be done. In general, it appears that further weight savings might be effected by providing more shock absorption for landing and taxiing, as this will reduce the magnitude of the loads for which a large part of the airplane structure must be designed.

FLUTTER AND COMPRESSIBILITY

The important problem of flutter is rather difficult to classify. Although structural theories and measurements are involved, from a research standpoint the problem appears to be more aerodynamic and mechanical in nature. (The flutter group at Lockheed has recently been transferred from the structures department to the aerodynamics department.) Structural theory assists by predicting the stiffness of the structure, but a more direct approach is to measure the natural frequencies by vibration tests while the airplane is on the ground. Mechanical engineers should be interested in the possibilities of flutter-prevention devices. If such devices could be made light enough they could replace present methods of balancing movable surfaces and thereby save a considerable amount of weight. Ordinary "dashpot" devices cannot usually be used, because of the complexity of the flutter modes and the danger of interfering with free movement of the control surfaces. The difficulty of preventing flutter becomes greater as the speed of the airplane is increased. In addition, "compressibility" effects must be considered as we approach closer to the speed of sound (a 500-mph airplane would certainly be thus affected). Flutter research must, therefore, be vigorously pursued on all fronts, in spite of the great advances that have been made in this field during the past few years.

Compressibility is rapidly becoming an important aerodynamic problem for all high-speed airplanes. Since sound travels more slowly at high altitudes, while the true air speed of supercharged airplanes tends to increase with altitude, the modern trend toward high-altitude flying and fighting has brought us rapidly closer to the compressibility problem. The structural engineer is interested primarily in its effect on the distribution of air loads on the structure and in the increased values of local air pressures. The problem is essentially aerodynamic, however, and is beyond the scope of this paper. It can be said, at any rate, that as usual the net effort will be to require stronger structure, which means still more weight to contend with.

Summarizing the foregoing points on external loads, the greatest need appears to be for additional statistics from actual flight and landing conditions. The most valuable form of such statistics would consist of frequency-distribution curves for the strains developed in various parts of the airplane structure. Analytical methods of attack should be further developed and applied, particularly for the case of taxiing over rough ground. It would also seem that further attention should be given to the problem of shock absorption, with a view to finding the optimum design which would give the lowest over-all weight for the airplane. Flutter research must be continued, with particular reference to mechanical methods of preventing flutter.

INTERNAL AND ALLOWABLE LOADS

After the external loads acting on the airplane have been determined, it is necessary to find out how these loads are distributed through the structure. The mass distribution of the airplane determines where the loads go, but it is the stress analyst's job to find out how they get there. The methods of analysis developed for other types of structures are generally applicable to the airplane, with a few exceptions and refinements which will be discussed.

In dealing with different structural components it is convenient to combine the subjects of internal and allowable loads, although they are kept fairly well separated in an actual analysis. For the present purpose of discussing research problems, the type of structure will be used as a basis and no effort will be made to distinguish clearly between internal and allowable loads.

Trusses and space frameworks are quite adequately covered by available literature and data. In recent years, attention has been directed mainly toward the problems of end fixity and moment distribution, in an effort to obtain a more accurate understanding of the interaction which results from "continuous" joints.

Relaxation methods, originally introduced in this country by Prof. Hardy Cross (6), and highly developed by Professor Southwell (7), have proved to be most useful, particularly for continuous beams having several supports. Modern airplanes usually have a relatively small amount of structure which falls in this category, because of the almost universal use of the shell and plate types of structures (metal skin). Hence, it would seem wasteful to devote much research effort to the framework, the continuous beam, and the beam column, in so far as the airplane is concerned. Graphical methods of solving beam columns have always seemed to attract many investigators, with the result that this subject is relatively overdeveloped, compared with other subjects of much greater interest to the modern airplane designer.

Rings and frames continue to be of special interest to airplane designers, particularly at the juncture of shell structures (wing to fuselage, for example). To be of use, methods of analysis must be capable of handling any arbitrary shape, any loading condition, and should permit consideration of stresses beyond the elastic limit. Too much emphasis has been placed on the academic side of this problem. The present state of knowledge is fairly complete, however, and the only remaining need is for a general "cleaning up" and organization of all the best information, including test data.

The solid beam is usually treated by the classical beam theory ($F = My/I$), which assumes a linear variation of strain over the cross section and a constant ratio of stress to strain. Departures from these elementary assumptions have been covered indirectly by the use of a modulus of rupture, which is in reality not a true stress at all. In airplane work, where weight saving is so important, it has been necessary to employ further refinements, particularly because of the use of new materials having different types of stress-strain diagrams. The variety of cross-sectional shapes used also complicates the problem. The theory of bending in the plastic range is not at all new, but it seems to have been greatly overlooked in practical application.

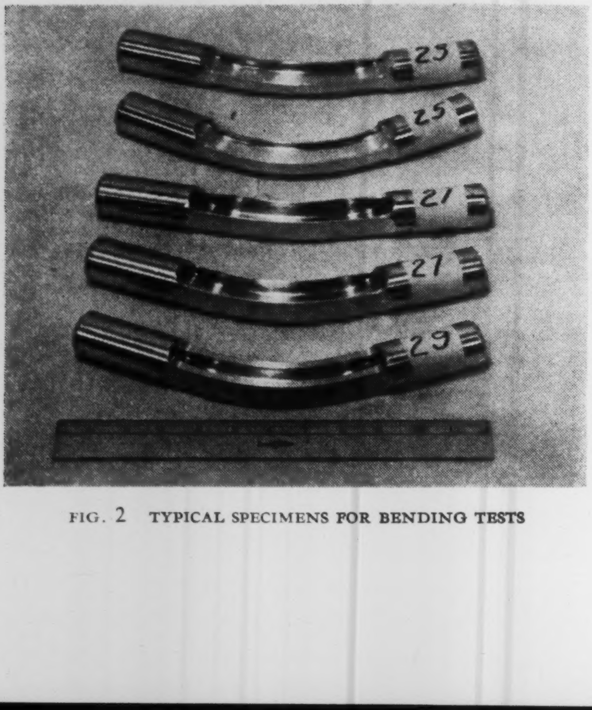

FIG. 2 TYPICAL SPECIMENS FOR BENDING TESTS

At Lockheed, we have recently completed a small series of tests of a family of shapes, to determine a suitable method of predicting the failing load in bending. Fig. 2 shows some of the specimens tested. By utilizing the stress-strain diagram of the material it has been possible to correlate the bending theory with actual test results. Charts have been derived from which the ultimate and "yield" bending moments may be determined for all the materials commonly used for casting, forgings, and machined parts. A paper[2] is in process covering the entire development, which was carried out by the Stress and Structures Research Groups at Lockheed. Much more work remains to be done to extend present knowledge into the fields of torsion, combined axial load and bending, combined torsion and bending, and various cross-sectional shapes. In the thinner sections the effects of local buckling and instability will have to be considered. We must also be able to predict the loading which will produce the first permanent set, as well as the ultimate load.

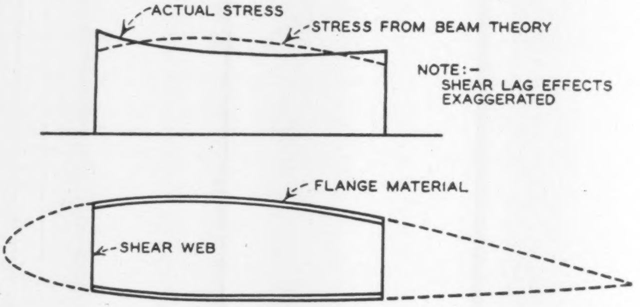

FIG. 3 SHEAR-LAG EFFECT IN WING BEAM

Considering the amount of weight represented by bulky parts, such as control horns, pedals, forgings, etc., it is surprising to find that so little has been done in this field. No doubt there is much information not readily available to the airplane designer, but to be of greatest use such information would have to apply to "aircraft" materials, particularly the forging and casting alloys of aluminum and magnesium.

SHELLS

The shell type of beam is widely used in modern airplanes, particularly for fuselages and wings. In determining the axial stresses due to bending, we find that the classical beam theory again has serious shortcomings. Under pure bending (no shear) the assumption of plane cross sections is valid, provided that the bending moment is applied in accordance with the theory (i.e., linear strain variation) or, alternatively, that the cross section is far enough away from the point of application so that end effects can be neglected.

However, when the bending is the result of a shear load which is being transmitted by the structure we are no longer safe in assuming that plane cross sections remain plane. In the case of a wing shell such as sketched in Fig. 3, for instance, the increments of axial loads in the top and bottom, as we move from tip to root, are applied along the lines of attachment of the "vertical" shear webs and must travel across the "horizontal" flange material. This relatively long path permits appreciable shear deflections which cause the cross section to distort from the assumed plane section. The result is an increase in axial stress in the flange material near the webs and a decrease in that portion farthest away from the webs, as compared with the results of the classical beam theory.

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[2] "Bending Strength in the Plastic Range," by F. P. Cozzone, presented at Annual Meeting of the Institute of Aeronautical Sciences, January, 1943.

This so-called "shear-lag" effect has received much attention in recent years, and methods of handling it in stress work are now available. One important point that has received too little attention is the effect of the geometry of the structure, particularly the effects of taper in depth and width. It can easily be seen that if the beam flanges were made wider from tip to root at such a rate that the new flange material added just took care of the new axial loads added by the webs, there would be no "shear lag." Most wing beams tend to approximate this condition; in fact, the optimum design for maximum efficiency would give just such a beam.

As shown by Cozzone and the author (8), the use of the classical beam theory and its companion shear formula (shear flow = SQ/I) gives a misleading picture. The "unit method" of analysis was therefore adopted, to take care of the effects of taper in depth and plan form. This method also reveals the effects of abrupt changes in distribution of flange material, such as found at cutouts.

The problem of shear lag may become important in some cases, but in general is felt to be less critical, from a weight and safety standpoint, than that of cutouts, to be discussed later.

Actual use of the "unit" method of beam analysis, as described elsewhere (8) and (9), has shown the need for a "three-dimensional" beam theory. For instance, it is not uncommon to find that the neutral plane for an actual wing structure has "steps" in it, as well as abrupt "twists." These, of course, indicate that the beam material has not been distributed as uniformly as might be desired. (If the discontinuities are too bad, the design should be changed, but this cannot be carried to an extreme.) It does not seem possible for the neutral plane to have abrupt discontinuities of this nature. We have tried "fairing" it in some arbitrary manner and have found that this greatly improves the flow of axial loads and reduces the local shear flows. Strain-energy checks also show that the faired neutral plane involves less strain energy, hence is closer to true conditions. Without some such modification, the "unit" method will indicate fictitiously high local shear flows wherever there is a slight disturbance in the continuity of the structure. The proper type of modification to use is a research problem for the future and is closely connected with the cutout problem. In any case, "spanwise" variations must be brought into the picture in some manner.

The shell type of beam usually must resist some torsion, in addition to the direct shear and bending loads which it carries. In analyzing a shell for torsion, it is customary to use the simple shear-flow formula $q = T/2A$, where q is the shear flow, T is the torque, and A is the area enclosed by the median line of the shell skin. In contrast to the beam theory, this formula is based on the assumption that the cross section is free to warp. This causes something of a dilemma, as the same structure obviously cannot behave in two different ways.

Fortunately, the same tendency to warp which caused the beam theory to become inaccurate also tends to make the shear-flow formula more nearly correct. It has been proved by theory and tests, for instance (10), that the errors are greatest at the point where the structure is forced to maintain a plane cross section. The effect dies away quite rapidly and becomes negligible at some distance away from the point where the cross section is forced to remain plane.

In an airplane wing symmetrically loaded, the plane of symmetry acts like a rigid plane bulkhead. Hence, the torsional-restraint effect will be a maximum at the root of the wing. This effect not only changes the shear flow around the shell but also introduces additional axial stresses in the flanges and webs. Some of these will add to the axial stresses produced by bending, while others will subtract.

The subject of end restraint in torsion is now fairly well understood. Considerably more work needs to be done, however, on the problem of introducing a large "local" torque at some intermediate point on the shell structure, such as at the nacelle and landing-gear attachments.

CUTOUTS

Cutouts in shell structures represent one of the meanest of problems facing the airplane designer. Except in the dreams of stress engineers, there has probably never been an airplane in which cutouts of some sort were not present. Modern military airplanes are obviously very bad in this respect, as there are cutouts for armament, bombs, cameras, cargo doors, inspection openings, and many other necessities. It is obvious that a system of analysis for shell structure will be of little use unless it can be extended to include the effects of cutouts.

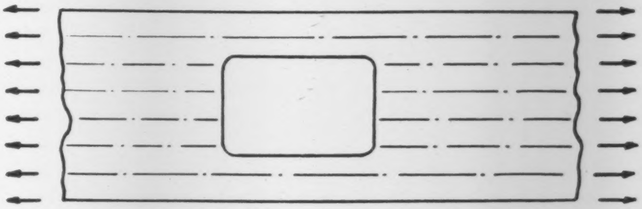

FIG. 4 CUTOUT UNDER AXIAL LOADING

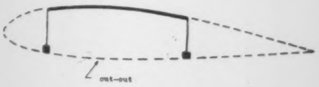

FIG. 5 LOWER WING CUTOUT

In treating cutouts, it is convenient to consider separately the effects of axial and shear loads. The usual approach in the case of a small cutout is to ignore it in the original analysis and then treat it as a local problem. The structure can be represented by a number of "flange units" each of which is carrying an axial load, as shown in Fig. 4. After the material is cut away, the loads in the cut elements must be diverted around the cutout. This introduces three problems: (*a*) Additional material must be provided along the edges, to avoid overloading the original material; (*b*) this material must be extended beyond the cutout far enough to permit it to pick up the loads from the cut elements; (*c*) additional shear material may have to be provided to take care of the high local shear flow caused by the rapid transfer of axial load. These three problems are obviously interrelated in a very complex manner.

The key to the analysis and design of a cutout of this type is a knowledge of the manner in which the axial load "decays" in an element which has been abruptly or gradually cut off. This will depend, of course, upon the stiffness of the surrounding material, the distance through which the load must be transferred (laterally), and several other secondary variables. Many simple tests could be made to obtain basic data on this important problem.

In many cases, the cutout is surrounded by a frame, which may be relatively stiff against bending in the plane of the shell. In such cases, the frame may play an important part in the transfer of load and will be subjected to high bending stresses, particularly at the corners. It is also common practice to add an extra plate or "doubler" all around the cutout. This helps carry both the axial and shear loads. If the cutout does not occur in a highly stressed portion of the structure, this simple treatment may suffice.

A very important type of cutout is often found in the bottom of a wing structure. Sometimes the entire bottom is cut away between the shear webs leaving a structure such as shown in Fig. 5. All the lower flange material must be concentrated at the shear webs. This type of cutout is particularly difficult to analyze in torsion and has a serious effect on torsional rigidity if it extends over some distance.

The effect of a small cutout in a shell carrying torsion (or pure shear) is somewhat similar to its effect under axial loads, except that two axial fields now exist, i.e., tension and compression at 90 deg. (In some cases the tension field will predominate, due to buckling under the compressive forces.)

If the cutout is small, a heavy frame can be used to replace the material removed, particularly in the case of round or oval cutouts. This frame will tend to be distorted under the action of the shear forces. If it is not relatively stiff under such loading, it will permit the surrounding structure to attempt to carry the loads which would normally have gone through the cutout. Much useful information could be obtained by designing and testing cutouts with various types of frames. At present there is very little information to guide the designer in his efforts to do the job with minimum weight.

If the "shear" cutout is large, a frame may become impractical as the method of reinforcement. It is then necessary to divert the shear flow into the structure surrounding the cutout. This requires, at the ends of the cutout, bulkheads or ribs capable of redistributing the shear flow. An elementary attempt to analyze such a case may be made by using the shear-flow formula ($q = T/2A$) and applying the beam theory over the portion containing the cutout. Test data indicate that large errors may be introduced by such methods because of the rapidly changing local conditions.

All of these cutout problems indicate the need for much more attention to local "disturbances" rather than further refinement of the "ideal" cases. One reason for the lack of data and literature on such subjects may be that they are most difficult to handle by formal elastic theory and mathematics. A semiempirical approach seems to be necessary, in which empirical (test) data on load transfer or decay are used in conjunction with the basic conditions of equilibrium and continuity. Relaxation methods of analysis should prove most useful in this connection.

BUCKLING—INSTABILITY

Before proceeding further with the major problems of shell analysis, it is necessary to discuss the important problem of instability. We can practically omit the simple column from this discussion, as structural literature abounds with column theories and experiments. At the present time, the airplane designer uses the charts in ANC-5 (11) for steel- and aluminum-alloy tubing. The "tangent-modulus" theory has been shown to be quite accurate as a basis for the prediction of column curves for any new material, provided that the compressive stress-strain diagram is available (12, 13). Professor Van den Broek has recently written an interesting paper (14) in which he advocates the use of eccentric-column theory as a basis for column analysis. There is, of course, no argument about the effect of initial eccentricity, but it would seem that our present knowledge of ordinary column failure is so far beyond our knowledge of other structural problems that the subject should be closed "for the duration."

The buckling of flat plates has likewise received much attention and the theory is well worked out (15). Complete data are lacking, however, on the conditions which cause permanent buckles. In most stiffened shell structures, the sheet may buckle before the ultimate load is reached. The usual buckling theories give only the load at which buckling begins. If the sheet is restrained by stiffeners, it will usually be impossible even to detect any buckling at the theoretical load.

In modern airplane work, there are actually three different criteria to meet:

(*a*) No visible buckling in normal flight (typical load-factor range: 0.75 g to 1.25 g).

(*b*) No permanent wrinkling at "limit" load (varies from 3 g to 8 g, approximately, depending upon type of airplane).

(*c*) No failure below required "ultimate" load (usually 1.5 times "limit" load, i.e., 4.5 g to 12 g).

Part (*a*) is covered fairly well by the existing buckling theories. Part (*b*) is more difficult and there are relatively few data on it (16). Part (*c*) involves the failing of the stiffeners and also the problem of "effective width."

Much work has been done on the "effective-width" problem (17). In fact, the author is inclined to believe that too much time has been spent on the theory, as it is relatively easy to test a small panel representing the structure in question. Such a test takes care of many troublesome factors; such as local buckling of stringers, inter-rivet buckling of sheet, twisting of stiffeners, effect of sheet wrinkles on stiffener strength, etc. At Lockheed we have made attempts to correlate all our panel test data by means of existing theories, but up to this time we still find it advisable to make a few panel tests whenever we depart very far from combinations already tested.

While on the subject of panel testing, it is recommended that more attention be given to end fixity, as affected by various factors present on the airplane. There is much confusion and argument on this subject. Some of the typical factors involved are:

(*a*) Different adjacent panel lengths.

(*b*) Restraint from ribs and bulkheads.

(*c*) Effects of lateral loading (air loads, water loads, etc.).

(*d*) Influence of bending curvature (as in a wing under bending loads).

(*e*) Plastic (short-column) range.

Stewart Way cleared up many of these points in an article in 1935 (18). Other valuable work has been done since, but not in proportion to the importance of the problem. The coefficient of fixity may actually vary between 1 (or even less) and 4. The arbitrary selection of a value of 1.5, for instance, would represent a 50 per cent increase in strength over a pin-ended column (in Euler range). How many other cases can be found in which the designer knows so little about such powerful variables? Considering that the largest single share of structural weight is involved in such structure, we cannot afford to be too "conservative" in order to cover our lack of knowledge.

Another effect that should yield valuable weight-saving results is that of edge restraint. In wings, for instance, the four corners of a single-cell box beam are often heavy "cap strips" which are completely supported against column failure. Very high failing stresses can be obtained from such bulky members, when so supported. Yet the sheet-stringer material adjacent to the cap strip may have a relatively low allowable load as a separate column. Certainly we can expect some benefit from the cap strip, particularly in cases where the applied compressive stress is a maximum at the cap strip and drops off toward the center of the box.

This suggestion should be accompanied by a word of warning, however; if the cap strips are not considerably heavier, in proportion, than the adjacent material the conditions may be reversed and the corner of the box may fail first. Further investigation of this case may be in order, as there is very little information on the minimum size of cap strip required. To some extent, the problem is one of combined loadings, as the corner cap is loaded in compression and also acts as a shear-transmitting member. This would be specially severe if the shear web were designed as a tension-field beam, which would apply additional bending loads to the cap strip.

Shear beams of the plate or thin-web type have been thoroughly investigated, and the designer now has fairly adequate analysis methods and data. Much more work should be done, however, to determine the best (most efficient) design for various degrees of loading. At present there is a wide variation in ideas on this subject, part of which is due to the lack of a single co-ordinated source of information.

It should be possible to determine the best arrangement of material for different loading intensities, using a "structural index" such as Wagner's $\sqrt{S}/h$ or the square of this, S/h^2, where S is the shear load and h the depth of the beam. (Such indexes will be discussed more fully later in this paper.) It will be found, for instance, that the truss type is lightest in the lower range, the thin-web type in the intermediate range, and the heavy plate girder or corrugated web in the heavy loading range. Various companies have made studies of this sort, but it is not likely that any of them has been able to assemble and digest all of the available test data on the subject.

The shear beam which tapers in depth is of special interest to the airplane designer. This subject was relatively neglected for a long time, but it is encouraging to note an increased number of papers in this field. Too many of these are of the "classical" or academic type, however, and are of little immediate use to the designer.

Curved shear beams are widely used in airplanes, as in fuselages, nacelles, and "D-tube" types of wings. Much less information exists than in the case of flat beams. If the sheet is sharply curved, it will resist high shear loads before buckling, but will tend to form a permanent wrinkle when it does buckle. The slightly curved thin-web beam, on the other hand, behaves more like the flat beam, the wrinkles forming early and disappearing when the load is removed. Stiffener spacing and strength play an important part. The optimum arrangement for different degrees of curvature and intensities of loading is again a fertile field for further research and development work.

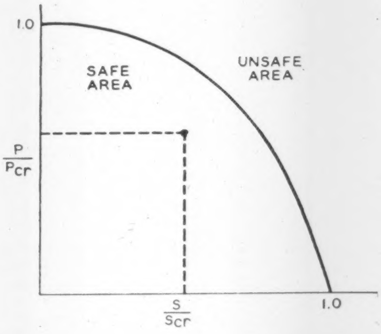

FIG. 6 INTERACTION CURVE FOR COMBINED LOADING

It should be noted that the laboratory testing of shear beams, particularly curved ones, presents a serious problem. It is very difficult to reproduce, in a jig, the exact conditions which would exist in the airplane. Hence, it is usually necessary to construct special jigs or to test the entire structure.

COMBINED LOADS

Combined loads are always encountered in airplane structures. This subject has been sadly neglected, as most investigators and authors seem to prefer to take up the simple loadings and leave it up to the designer to figure out how to combine them in actual practice. The interaction curve, or stress-ratio method (19) has been found to be quite valuable as a means of bridging the gap between the different loading conditions. An interaction curve is sketched in Fig. 6, indicating how it is used to handle combined axial and shear loading. Terms P_{cr} and S_{cr} are the allowable (critical) loads for axial and shear loading, respectively, while P and S are the actual applied loads. The dotted lines indicate one particular combination of loads.

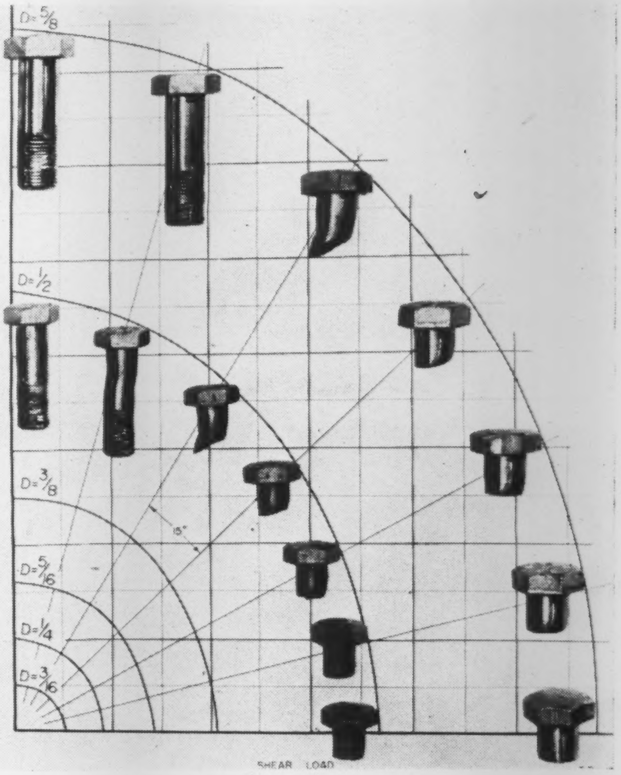

FIG 7 FAILURE OF BOLTS UNDER COMBINED SHEAR AND TENSION

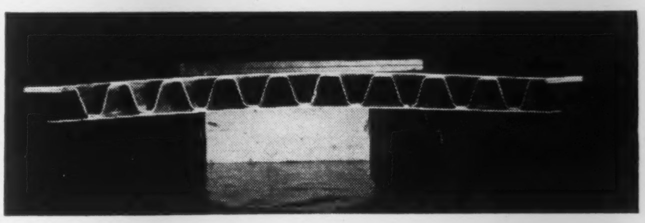

FIG. 8 "CARDBOARD-BOX" TYPE OF DOUBLE-SKIN PANEL

This type of curve has the advantage of always being correct at either end; thus if one loading condition predominates, the error caused by a poor assumption for the interaction curve cannot be large. Furthermore, when data on the combined conditions are scarce the curve can be drawn conservatively. A straight line between the two end points will be safe in practically any case except one in which secondary effects occur (such as combined axial and bending loads, where the axial loads increase the bending loads).

The interaction-curve method eliminates the need for a detailed investigation of each case, a point which is of great value in actual stress work. Fig. 7 shows how this idea has been applied in the case of bolts loaded in combined tension and shear. (Lockheed test data.)

General instability is an important phenomenon in which buckling failure occurs over a relatively large area of the shell, including both longitudinal and transverse stiffeners. This sub-

FIG. 9 SPACER TYPE OF DOUBLE-SKIN PANEL

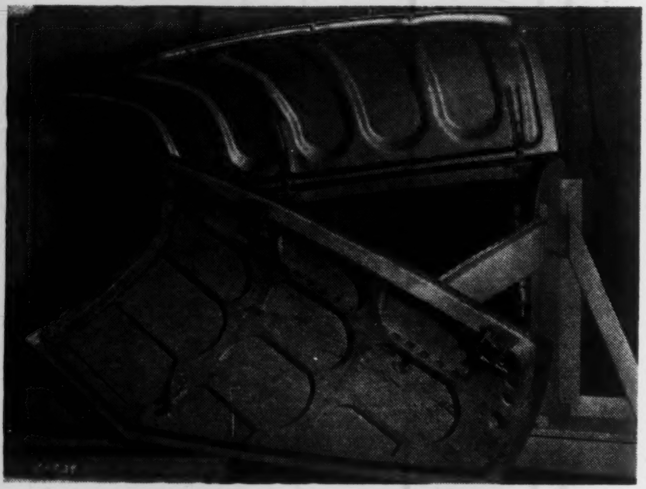

FIG. 10 USE OF INNER STAMPING

ject has been under investigation by the California Institute of Technology for the past several years and valuable results have been obtained. The work is being carried on under the sponsorship of the N.A.C.A. The subject is of particular importance in the case of very large airplanes, as it would be inefficient to use frames or bulkheads any heavier than necessary. Internal space is always at a premium in an airplane, so it is desirable to use relatively shallow frames or rings. Another application of this theory is found in wings of the shell type, where ribs have been removed or reduced in depth to provide room for bombs or bulletproof tanks. The general instability problem is a typical example of a structural theory which was practically unheard of until the thin shell structure of the airplane necessitated its development. Some of the earlier work on this subject has been described (20, 21).

Before leaving the subject of shell structures, it might be stated that the present trend of design appears to be toward the double-skin type of construction. This may take the form of the "cardboard box," Fig. 8, the "separator" type, Fig. 9, the "filler" type, or the "inner stamping," Fig. 10. Most of these ideas have actually been used in Lockheed airplanes. The double skin represents the most efficient use of the material in bending and shear, as compared with sheet-stringer construction. The trend in production is also in this direction, as it is desirable to eliminate the use of a large number of separate parts.

JOINTS AND FITTINGS

Joints have always been the weak links in most structures. Since it is impossible to make a riveted or bolted joint in sheet metal without reducing the cross-sectional area of the sheet, the structural efficiency of all parts of the structure critical in tension is governed by the efficiency of the joint itself. (This would not be true if we could get sheets with a variable thickness.) From a weight-saving standpoint, refinement in joint design is therefore very important. The demand for flush external joints on an airplane makes the problem more difficult, as it leads to eccentricities and the use of countersunk screws and rivets. Spotwelding does not improve matters much, as the strength of an aluminum-alloy sheet is reduced considerably by a row of spotwelds. It would seem worth while, therefore, to conduct a systematic investigation of tension joints in sheet metal, bringing together all available data and supplementing these by additional tests, if necessary. Such tests should include "removable" joints made with flush-type screws. Such joints have a tendency to slip or open up at relatively low loads.

Fatigue tests of joints are very much in order. Lockheed has made many such tests to determine the relative merit of different types of rivets, screws, and bolts. A relatively neglected subject is the fatigue strength of bolts in shear. Actually it is the bending action which causes the most trouble in this connection. Hence, we find that under repeated loading it is advisable to use relatively short bolts. Further work on this subject may indicate the advisability of using multiple-lug or "piano-hinge" types of fittings. Fig. 13 is a picture of one of the Lockheed machines on which joints are tested under repeated loading.

Stress concentration and fatigue will always be an important pair of subjects for research. Photoelastic methods have proved to be a powerful tool in understanding the flow of strain below the elastic limit. For members which are subjected to violent and rapid alternating stresses such methods are directly applicable, as the endurance limit will be relatively low. But there are few places in an airplane structure that will ever be subjected to such violent conditions. Hence, we need more knowledge of stress-concentration effects in the plastic range and more fatigue data representing occasional loadings of relatively high magnitude. The literature on fatigue has recently shown such a trend.

The photogrid process may be of some use in determining the flow of strain beyond the elastic limit, if sufficient refinements can be made (22).

Under present war conditions, there will not be so much emphasis on long service life; hence our fatigue problems will be confined largely to structures subjected to constant vibration, such as those near the propeller tips and around the engine cowling. However, we cannot afford to forget that the service life of the future transport airplane may be many thousands of flying hours, and we must be prepared to tell the designer where he may have to place some extra material to prevent fatigue failures after long service. This, of course, ties in with the collection of flight statistics, mentioned in the first part of this paper.

Impact resistance is an important research subject. The low temperatures encountered at high altitudes have caused an increased amount of investigation in this field. Perhaps too much emphasis is being placed on the properties of the materials, however, and not enough on the design of the parts. The effects of "triple-tension" or biaxial-tension loading are likely to be much more important than the selection of special materials. Such effects are usually combined also with stress concentrations, "stress raisers." The net result is that the material tends to behave like glass, even though its nominal impact characteristics may be good.

The full-scale testing of actual parts under impact loads appears to be the best way to obtain useful data on impact. At

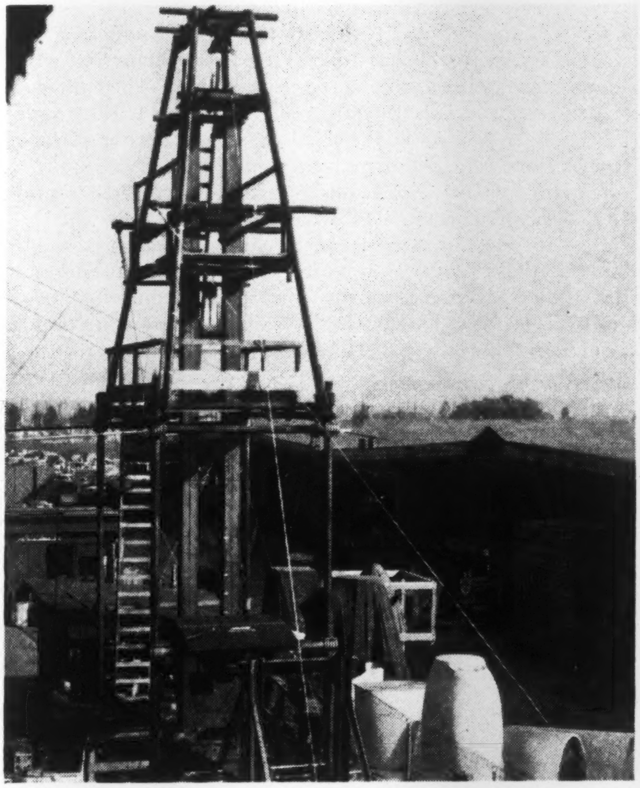

FIG. 11 "PILE-DRIVER" IMPACT-TEST JIG

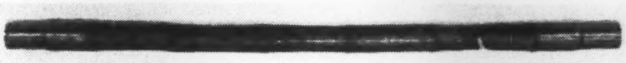

FIG. 12 FLASH-WELDED SPECIMEN AFTER IMPACT TEST

Lockheed we have constructed a very simple "pile driver" in which heavy weights can be dropped a distance of 29 ft, Fig. 11. This machine enables us to break large specimens under conditions similar to those of actual service. The most recent tests have been on flash welds. A typical specimen, after testing, is shown in Fig. 12.

STRUCTURAL INDEXES

Structural engineers seem to be slow in recognizing the usefulness of the principle of dimensional similarity. Perhaps this is because most writers on this subject emphasize the use of small-scale models, rather than the more general application of "structural indexes." Small-scale models are, of course, very useful and will become more important as the size of the airplane increases. The greatest obstacle to their use, to date, has been that any considerable reduction in scale will usually require sheet thicknesses that are too flimsy to be practical, rivets and screws that must be specially made, and other details which, taken together, often turn out to make the model at least as expensive as the full-sized specimen.

The real value of similarity principles lies in the fact that every structure actually represents an infinite family of structures, obtained by multiplying every dimension by a numerical factor. The strength, stiffness, and behavior of every member of this family can be predicted without further analysis or tests, if these characteristics are known for one member. Thus if a certain structural component were expanded in every dimension by a factor of 2, the strength would increase 4 times. Furthermore, if the original structure happened to be the most efficient type for the particular conditions involved, the expanded structure would also represent the optimum type for the new conditions.

Since structural research is aimed primarily toward finding the optimum structure for the design conditions encountered, the application of this principle must be considered as an essential part of such research. Likewise, it should be possible to reduce the design and analysis time considerably by taking advantage of all the structures that have previously been designed and tested.

The key to the practical application of similarity principles is the use of a "structural index," or "coefficient." (The word "index" appears to be more logical than "coefficient," as the quantity involved can be thought of as "indicating" the nature of the loading conditions; furthermore, the factors are not nondimensional.) The structural index may be thought of as a factor describing the relationship between size and loading which is common to a whole family of dimensionally similar structures. Thus if a designer wishes to know whether the properties of a certain shear beam, previously designed or tested, would be just right for some new application, he would compare the structural indexes for the two conditions. If they were the same, he could "design" the new beam simply by multiplying all dimensions of the old one by the proper factor.

For example, assume that a shear beam or truss had been designed to carry a shear load of 5000 lb and that the depth was 12 in. The structural index would be, in this case, $S/h^2 = 5000/144 = 34.8$. Now assume that on a new design the depth available for the shear beam is 20 in. and the shear load to be carried is 14,000 lb. The index could be $14{,}000/400 = 35$, which tells us that the new beam belongs to the same "family" as the old one. The dimensions of the new beam may, therefore, be determined by multiplying every dimension of the old one by the ratio 20/12. Since the strength goes up as the square of this factor, the new beam will have almost exactly the required strength. Furthermore, if the original beam had been very carefully designed and tested, to give maximum strength/weight efficiency, the new beam derived from it would represent the same degree of efficiency.[*]

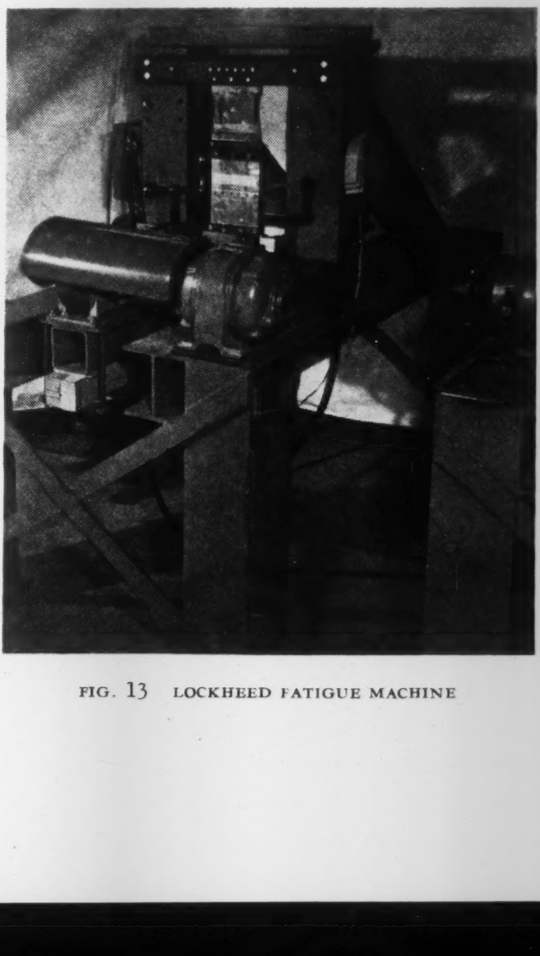

FIG. 13 LOCKHEED FATIGUE MACHINE

The "structural index" offers the designer a guide to the optimum type of structure. Once the design data for a range of indexes have been worked out, the designer can tell at once what type of structure he should use. Furthermore, it is possible to determine the relative efficiencies of different types of structures as a function of the structural index. This indicates how much of a weight penalty must be accepted if for some reason the optimum type of structure is not selected.

In actual practice the procedure would be to determine structural sizes and proportions on an "ideal" basis, ignoring available gages, rivet sizes, etc. After the "ideal" structure has been determined for a particular case, it is a simple matter to convert to practical dimensions. This procedure also indicates the weight penalty involved in having to use a limited number of sheet gages, etc.

The structural index is particularly useful in design work because it contains in it two things that the designer knows to start with. One of them is the intensity of the load and the other is a dimension which limits the size of the structure. For shear beams, it is the shear load and the depth of the beam; for columns, the axial load and the length of the column; for circular shells in bending, the value of the bending moment and the diameter of the shell, and so on. In contrast, the "stress-analysis" type of coefficient (such as slenderness ratio for columns, or section modulus for beams) does not contain any measure of the loading condition; hence "cut-and-try" methods must be used in selecting sizes. Perhaps too much emphasis has been placed upon determining the strength of an existing structure and not enough on the selection of a structure for certain existing conditions.

This subject is so attractive and has so many possibilities that it could easily absorb this entire paper. It will be impossible to take up here the various types of structural indexes already in use, or to indicate future possibilities. This general discussion has been included mainly to stimulate interest in this relatively neglected field.

MATERIALS

The controversial question of "which material is best?" has been deliberately left to the last. The facts are that there is really not a great deal of difference between various competitive materials, on a purely strength/weight basis. A clever designer can largely overcome the disadvantages of steel (mainly thinness) and can emphasize its advantages (spot-welding). Similarly, the corrosive tendencies of magnesium can be minimized by careful protection and good design, in order to take advantage of its lower density (greater thickness for the same weight). Even wood can still take its place along with the materials that pushed it out of the picture years ago and, in fact, has been making a considerable comeback recently because of critical-material shortages.

The final decision as to the type of material to use will involve many factors, the most important of which will probably be production. Obviously, no designer will accept a large weight penalty to improve production, but it should be remembered that only about 20 per cent of the gross weight of the airplane is subject to reduction through the use of improved materials.

Under present conditions it would be disastrous for a large company to attempt a large-scale change-over in the basic materials of construction. Every material has its peculiarities, extending down to such small matters as bend radii and the sharpening of drills. Countless hours of research and experimentation with details have been spent to "lick" the little everyday problems that can ruin the production line. It is not hard to realize why large aircraft manufacturers are reluctant to make any major changes in materials.

Improvement in the materials already being used is, however, of greatest importance. Anything that can be done to increase strength without seriously interfering with production will be incorporated in the design as soon as possible. The things that are being done are, in general, confidential, but it is safe to say that the war will have a decided effect on improving the efficiency of our future transport airplanes.

A paper on airplane structures would hardly be complete without some discussion of plastics. "Plastic plywood" will not be included in this term, as such structures should be thought of as "wood," in so far as the structural engineer is concerned. Much interesting work is being done toward the improvement of the strength of plastics. There is no question about the important part that reinforced plastics will play in the design of tomorrow's airplane. But the development of the plastic material is only a first step; the second step will be to work out all the design and production details, such as attachment methods, tooling, drilling holes, repairs, and similar practical items. In the author's opinion, we are about ready to enter this stage in the development of plastic structures. The future progress of plastics will depend largely upon how well and how thoroughly we do this job.

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WAR RUBBER PROBLEM *of the* UNITED STATES

By A. V. KARPOV

CONSULTING ENGINEER, PECKER, SIMPSON AND GLADECK

THE sudden loss of a natural-rubber supply created a problem of such magnitude that often it is not clearly realized. The problem of finding new supplies of rubber must not interrupt or disturb other war requirements. It calls for careful balance of rubber needs, available raw materials and plant capacities, and limited supply of critical materials.

SYNTHETIC RUBBER

Synthetic rubber is a chemical compound with the mechanical properties of rubber. Its chemical composition is not the same as that of natural rubber and to that extent the term "synthetic rubber" is misleading. It is not a synthesis of the molecules which constitute natural rubber but rather a synthesis of a basic unit hydrocarbon molecule. This basic unit, called a monomer, can be made to form chains which are repetitions, thousands of times, of the basic unit. These chains, also called giant molecules, have mechanical properties similar to those of natural rubber. The method of forming these chains is accomplished by polymerization.

Before the war the work on synthetic rubber in the United States had been directed toward the development of special kinds of rubber for particular applications in which they would be superior to rubber products made from the natural latex. Considerable success had been achieved in developing compounds which, although inferior to natural rubber in resilience and wear, were definitely superior in withstanding deterioration in contact with chemicals and oils.

After the reverses in the Pacific and the loss of natural-rubber sources, the synthetic product took on new importance as a substitute for the regular rubber requirements.

BUNA-TYPE RUBBER

In planning the synthetic-rubber program, the most important problem was to decide which kind of synthetic rubber to produce. The product had to meet the requirements of production in quantity, uniform quality, and similarity to the natural rubber, in so far as compounding, vulcanizing, and final manufacture are concerned. The latter requirement is of extreme importance in the face of shortages of materials, and it covers use of existing equipment.

Synthetic rubber meeting these requirements has been developed and very valuable experience has been gained with it in Germany and Russia. This experience is available only to the extent described in technical literature. Based on this experience and on laboratory research conducted in the United States, the decision was made to concentrate the major efforts on the Buna types of synthetic rubber.

The principal ingredient of Buna rubbers is butadiene which can be obtained in large quantities. It is the basic material of almost all the synthetic rubbers manufactured in Europe. According to present plans it will be used to produce about 845,000 long tons of Buna rubber per year in plants sponsored or owned by the government.

The remainder of the rubber program includes three special rubbers that were developed before the war. These are Thiokol, Neoprene, and Butyl rubbers. For some applications, these are expected to equal or excel Buna types. Thiokol is being considered for the recapping of tires; Neoprene is considered especially valuable where resistance to oil and acid is necessary; Butyl, a more or less all-purpose product.

As much natural rubber as possible will be imported from abroad. Large-scale cultivation of guayule has been begun in the United States, and it is expected that about 80,000 tons of natural rubber will ultimately become available from this source. With a peacetime annual consumption of about 600,000 long tons, the planned program of about 1,200,000 long tons annually when in full production ought to cover comfortably all military requirements of the United States, our Allies, and the reduced civilian needs as well.

The extremely critical period will be the interim when the available natural-rubber stock pile will have been used up and synthetic rubber not yet available in necessary quantities.

BUTADIENE

The basic hydrocarbon of Buna types of rubber is butadiene, the chemical formula of which is C_4H_6. This is the monomer which by means of polymerization forms giant molecules of synthetic rubber. At room temperature and pressure it is an inflammable gas, becoming liquid when the temperature drops to 23 F or the pressure is increased to 2.5 atmospheres (36.8 psi). In liquid form it can be stored or transported in steel cylinders or pressure-tank cars.

It may be obtained from petroleum-refinery gases or from natural gas as butane which can be readily changed into butadiene. From agricultural products it is obtainable via the intermediate manufacture of ethyl alcohol. The process in each case involves a rearrangement of the atoms in the molecule and is brought about by catalytic action under controlled temperature and pressure.

The manufacture of Buna type rubber is reflected in the diagram and may be summarized as proceeding in three steps:

1 Butane or butylene from natural gas, petroleum, or ethyl alcohol; the latter from petroleum or agricultural products.
2 Butadiene from butane, butylene, or ethyl alcohol.
3 Synthetic rubber from butadiene.

PRINCIPAL RAW MATERIALS

The materials from which synthetic rubber may be made are obtainable from sources which are numerous and plentiful. These sources are petroleum and several of the basic agricultural products (grains, corn, potatoes, or sawdust) which can be made to yield the necessary hydrocarbons.

In normal times these materials are so abundant that either the petroleum industry or agriculture could so completely supply a synthetic-rubber production industry as to constitute a monopoly. Enough petroleum is potentially available to produce more butane or butylene, the basic hydrocarbons, than necessary for the present program. Alcohol production for such a program could be met readily by production from almost any kind of vegetation and from paper- and lumber-mill wastes.

Under the pressure of war, however, both of these sources are badly limited. Added to this is the constantly growing list of critical materials, especially metals. Any attempt, therefore, to build a synthetic-rubber industry with the necessary speed to prevent possible military disaster could badly impair other war-production activities.

PETROLEUM-PRODUCT RAW MATERIALS

Oil companies have been active in developing processes for obtaining butadiene, which is basic to synthetic-rubber production. It is readily derived from butane, a petroleum hydrocarbon. Butane is a product of petroleum cracking and with it are produced numerous other hydrocarbons. Butane is also collected during the normal production of aviation gasoline.

The chemical balance of petroleum and petroleum gases is such that the yields of various hydrocarbons can be adjusted. The increased output of one hydrocarbon is made at the expense of one or more of the others. This is significant to rubber production because it places aviation gasoline and rubber in direct competition. Increase butane for rubber production, and aviation gas suffers. Since production facilities are fixed and the chemical balance is delicate, butadiene production from petroleum cannot be increased without decreasing the output of high-octane gasoline.

To overcome this limitation expanded facilities would be required. The building of new refineries is possible only with a considerable amount of critical materials. It becomes necessary, therefore, to convert existing refineries for the production of the maximum amount of high-octane gasoline. This production should require the smallest amount of petroleum gases to permit a maximum production of butadiene.

AGRICULTURAL PRODUCTS

Butadiene can be made from industrial alcohol. In the past, alcohol was obtained principally from molasses. The greatest supply of molasses was imported and, with small amounts produced in the southern part of the United States, it constituted a sufficient supply for industrial needs. Lack of shipping has affected the supply of molasses.

The available surplus of agricultural products was sufficient to cover any possible alcohol requirements. The agricultural product presently available in abundance is grain, and it appears that the production of industrial alcohol must be based mainly on grain.

The prewar demand for exceedingly high-proof alcohol was comparatively small and, after Pearl Harbor, a shortage developed. This was the result of the increased need for alcohol in smokeless-powder production. Add to this the need for butadiene and for other civilian uses and the required expansion of alcohol production becomes obvious.

The solution of this problem depends on a widespread program of conversion of existing fermentation plants into exceedingly high-proof alcohol plants; also conversion of molasses alcohol plants into grain alcohol plants. This conversion, as well as any building of new plants, must be based on a minimum expenditure of critical materials.

Reference to the accompanying diagram shows that the alcohol pool which can be made available from agricultural sources is great enough to supply all needs, including the synthetic-rubber program.

POLYMERIZATION

In polymerization, the butadiene monomers are made to arrange themselves into the giant molecules which are synthetic rubber. Such a polymerization can be accomplished with butadiene alone. The resulting rubber, however, is inferior. The real progress in synthetic rubber production was made when it was discovered that butadiene can be co-polymerized, i.e., the atoms re-arranged with the inclusion of other atoms in the molecule. Synthetic rubber of much higher quality may be obtained by the proper choice of additional ingredients. The next important discovery was that polymerization in an emulsion results in speeding up the process to such an extent that it becomes possible to produce synthetic rubber commercially in large quantities.

Butadiene and the ingredient are emulsified in water with addition of animal fats. To this emulsion is added either styrene or acrylonitrile, and this mixture in the presence of a catalyst is subjected to temperatures and pressures which cause polymerization. The resulting suspension of synthetic rubber resembles the latex obtained from the rubber tree. The process proceeds quite rapidly and requires close control of temperature and pressure but does not present any unusual difficulties. The rubber is recovered from the emulsion by coagulation with acetic acid.

The addition of styrene results in the production of Buna S. Styrene is obtained from benzol and ethyl alcohol, the benzol coming from coke-oven gases. It has been used in the manufacture of plastics and any increased demand can be met by expanding the output of an already well-established process. Benzol could also be obtained from petroleum if the need should become greater than existing facilities can meet.

Government-owned or sponsored plants will use styrene as the additional ingredient and will manufacture Buna S rubber.

SPECIAL RUBBERS

The production of Thiokol and Neoprene are established processes and no difficulties are expected in increasing the present production capacity.

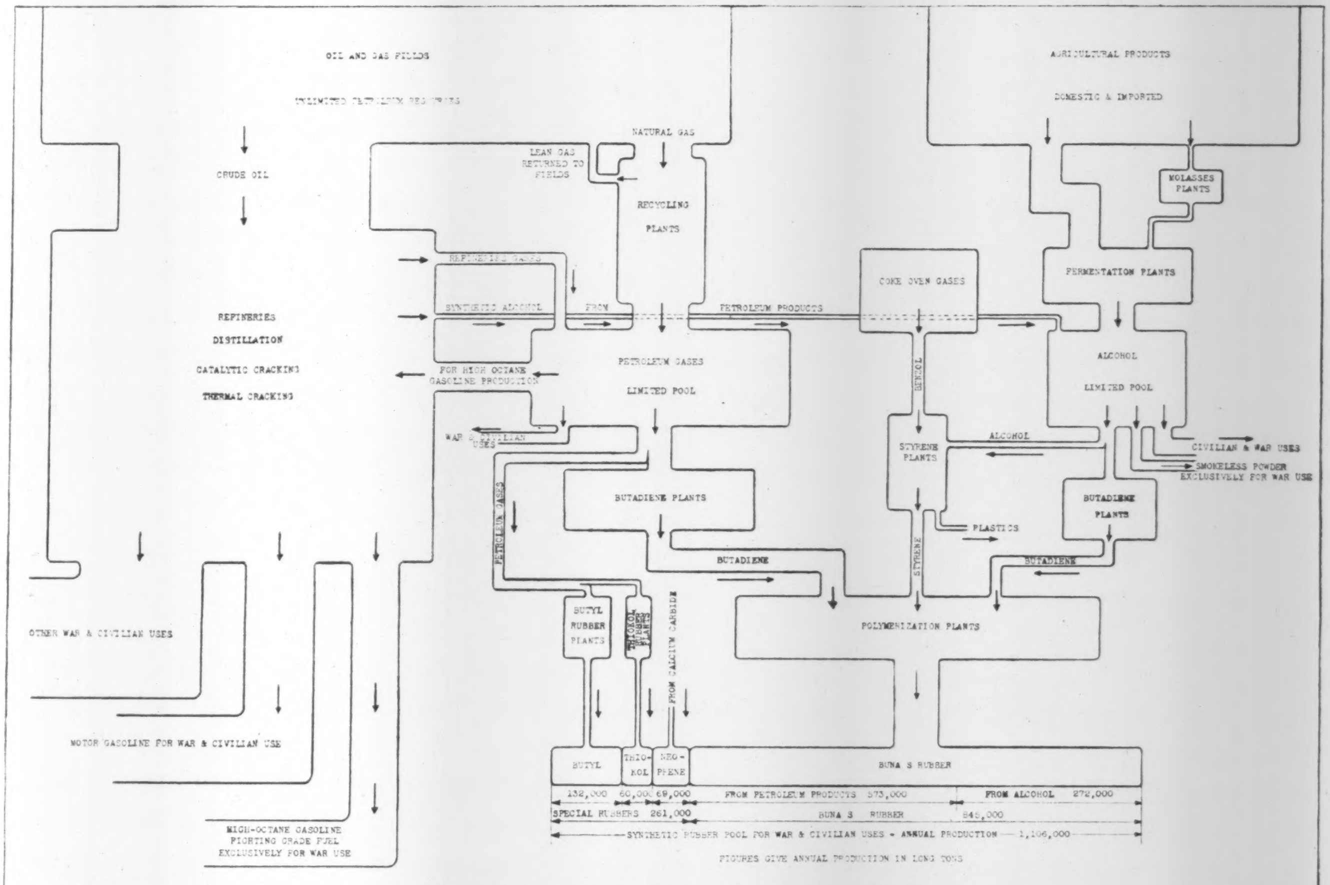
Thiokol is the only nonvulcanizable rubber included in the rubber program. The materials of which it is made are ethylene dichloride, a petroleum product, and sodium polysulphide, made from sulphur and caustic soda.

Neoprene is an American product and was introduced as far back as 1931 by du Pont. It has numerous civilian and military special uses. Raw material for this rubber is acetylene made from calcium carbide and hydrochloric acid. These give chloroprene which is polymerized to Neoprene.

Butyl rubber is made entirely from petroleum products by a process simpler and more direct than the manufacture of Buna types. It does not require an intermediate product like butadiene. The raw material is isobutylene, obtained from refinery gases. There has been no large Butyl rubber plant in operation in the past and Butyl possibilities have not yet been fully explored.

MANUFACTURING DIFFICULTIES

The basic processes involved in the manufacture of synthetic rubber are rather simple but the large-scale manufacturing processes may involve considerable difficulties. The normal development of a large chemical plant utilizing a new process requires a number of consecutive steps: First, the laboratory determination of the process; second, the building and operating of a pilot plant in which the laboratory processes can be expanded to approximate actual plant conditions; third, the building of a moderately large plant based on the experience of the pilot plant; fourth and final, the building of a large production plant based on the experience obtained in the previous steps and designed not only to produce the desirable product but to produce it in the most economical way. Such normal development should require several years. The war does not permit such a schedule. In many instances, it was even impossible to build pilot plants and operate them long enough to obtain the necessary experience. It became necessary to jump from the laboratory to the large-size plants.


OIL AND GAS FIELDS
UNLIMITED PETROLEUM RESOURCES
CRUDE OIL
NATURAL GAS
LEAN GAS RETURNED TO FIELDS
RECYCLING PLANTS
REFINERIES GASES
REFINERIES
DISTILLATION
CATALYTIC CRACKING
THERMAL CRACKING
SYNTHETIC ALCOHOL
FROM
PETROLEUM PRODUCTS
FOR HIGH OCTANE GASOLINE PRODUCTION
PETROLEUM GASES
LIMITED POOL
WAR & CIVILIAN USES
PETROLEUM GASES
BUTADIENE PLANTS
BUTADIENE
AGRICULTURAL PRODUCTS
DOMESTIC & IMPORTED
MOLASSES PLANTS
FERMENTATION PLANTS
COKE OVEN GASES
BENZOL
ALCOHOL
LIMITED POOL
ALCOHOL
STYRENE PLANTS
CIVILIAN & WAR USES
SMOKELESS POWDER EXCLUSIVELY FOR WAR USE
BUTADIENE PLANTS
PLASTICS
STYRENE
BUTADIENE
POLYMERIZATION PLANTS
OTHER WAR & CIVILIAN USES
MOTOR GASOLINE FOR WAR & CIVILIAN USE
HIGH-OCTANE GASOLINE FIGHTING GRADE FUEL EXCLUSIVELY FOR WAR USE
BUTYL RUBBER PLANTS
THIOKOL RUBBER PLANTS
FROM CALCIUM CARBIDE
BUTYL
THIO-KOL
NEO-PRENE
BUNA S RUBBER
132,000
60,000
69,000
FROM PETROLEUM PRODUCTS 573,000
FROM ALCOHOL 272,000
SPECIAL RUBBERS 261,000
BUNA S RUBBER 845,000
SYNTHETIC RUBBER POOL FOR WAR & CIVILIAN USES - ANNUAL PRODUCTION 1,106,000
FIGURES GIVE ANNUAL PRODUCTION IN LONG TONS

PECKER, SIMPSON & GLADECK SYNTHETIC RUBBER PRODUCTION AS AN INTEGRAL PART OF OUR WAR ECONOMY A. V. KARPOV

A number of obvious difficulties can be foreseen but the remedies are not very apparent yet. The first and most pronounced difficulty lies in the necessity of purification of all ingredients. The amount of purification of butadiene has an important bearing on the output efficiency of the rubber plants. Materials of high purity must be used for manufacture of butadiene.

Manufacturing butadiene in a sufficiently pure form is a problem. Because of its low boiling point (about 30 F) low-temperature low-pressure distillation is preferable. However, all refrigeration equipment that can be made available in the immediate future has been allocated to the production of aviation gasoline. Here again is the conflict in production between butadiene and high-octane gasoline. The less desirable high-temperature high-pressure distillation must be resorted to. Lack of experience, while it does not endanger the program as such, will affect its efficiency. This will be reflected in higher prices. With experience and increased efficiency, the cost will decline.

FINISHED RUBBER PRODUCTS

Because synthetic rubber is unlike natural rubber it is inevitable that compounding and vulcanization methods must be developed which will differ to a certain degree from the methods to which the rubber industry has been accustomed in the past. The theory of rubber manufacture is insufficiently developed and, therefore, compounding and vulcanization are processes which must be determined empirically. As a matter of fact, the most important discoveries, vulcanization of rubber, adding of carbon black for manufacture of tires, and many others were made by accident rather than because of clear scientific understanding of the underlying natural phenomena. It seems likely, therefore, that with the substitution of synthetic for natural rubber and continued study in the field of rubber, many discoveries will be made which will improve the final product. Time being as short as it is, experience gained in Russia should prove valuable in our program and should help to avoid some manufacturing difficulties. At the present time the Office of the Rubber Director, War Production Board, is working with Russian engineers on the manufacture and production of synthetic rubber.

SYNTHETIC RUBBER AS AN INTEGRAL PART OF WAR ECONOMY

It is needless to mention the numerous ways in which hydrocarbons are vital to modern living. However, with the natural-rubber supply beyond reach, the hydrocarbons have taken on a new and greater importance. Although the hydrocarbons are available in nature in practically unlimited quantities, the amounts which we are equipped to produce under war conditions are limited.

The building of a synthetic-rubber industry requires a careful balancing of the available hydrocarbon supply and the available processing equipment. The diagram shows how the production of synthetic rubber is to be balanced by the need for other vital war materials using the same raw-material sources. With the exception of rubber no exact quantities or figures for raw materials or by-products are presented. The flow of the various materials is given on an approximately proportional scale.

The amount of oil and natural gas in the nation's fields are practically unlimited as far as the war is concerned. The building and expansion of gas recycling plants and oil refineries,

(*Continued on page 207*)

WOOD—*the Most Important* RAW MATERIAL *of the* FUTURE

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MATERIAL stringencies brought about by war conditions have given a new significance and perspective to the place wood occupies in modern civilization. Wood always has been a useful material, but for many years it has been considered largely in terms of building construction, shelter, furniture, flooring, packaging, and some industrial uses.

Among the latter, for many years, we have made paper, chemicals, and preservatives from wood. Now it is being used as a source of explosives, medicines, oils, clothing, plastics, and many other products.

Wood is likely to be more important to civilization than metals, minerals, oil, rubber, ceramic products, and many others. Why? Because:

1 It has such universal application and use.

2 It is abundantly available in a great variety of textures, hardness, durability, strength, pliability, workability, and other desirable features.

3 It is relatively inexpensive compared with other materials.

4 It is replaceable. An improved plan of forestry indicates that we can grow all the wood we need in this country and perhaps for a substantial export trade.

These are four fundamental factors which should be carefully reviewed and studied for the future of the American economy, particularly in the postwar program. If fire and other enemies are controlled, and an effective plan of forest management is practiced, there will be all of the wood necessary for all of our requirements.

WAR NEEDS HAVE WIDENED THE FIELD OF APPLICATION

At present, six types of American planes are being built of plywood, about twelve are being designed of plywood, and several European warplanes, particularly English bombers, are largely made of birch plywood.

The consumption of plywood has advanced comparatively beyond that of any other timber product and especially during the recent ten depression years. Although the increased use of plywood is enormous, the possibilities of its greater use in times of war and peace are almost beyond conception.

The War Production Board has recently banned the manufacture of some 800 items of steel and other metals, ranging from coat hangers to refrigerators. Wood is being called upon to take their places. Plywood is going to "carry the ball" in many of them and will remain in permanent possession for many purposes formerly held by other materials, if people interested in wood have the foresight, vision, and ability to hold that market.

Truck and automobile bodies are once more being built of wood. Plans for the production of trucks with wooden bodies were geared up to the rate of 1000 a day in July; 1500 a day by the end of 1942. These trucks require about 1000 fbm each, so the daily consumption for this one use is about 1,000,000 fbm Recently, the Army ordered 880,000 trucks and trailers in one day. This one order is estimated to save 75,000 tons of steel in 1942, and 850,000 tons in 1943.

The construction of wooden ships has had an enormous development under the impetus of war conditions requiring the conservation of steel. These vessels range in size from small military barges and patrol boats to seagoing tugs and coastal freight ships. Oak, the premier species for boatbuilding has not been available in sufficient quantities for some shipyards and other species are more widely used. Smaller craft built of veneer have received wide attention and recognition. Water-resistant glues have made this possible.

Freight cars with metal underconstruction and framing, and plywood and lumber roofing and siding are claimed to be better than all-steel construction.

Today about 10 to 15 per cent of our normal lumber production goes into industrial packaging. Plywood is playing no small part in this development.

Steel desks, filing cabinets, furniture, and other forms of office and household equipment were removed from sale some time ago. Many wooden trusses up to 132-ft span have already replaced steel for hangars, warehouses, and many permanent and temporary structures. Steel concerns have even turned to wooden members for much structural work.

KNOWLEDGE OF WOOD PROPERTIES NECESSARY FOR EFFICIENT UTILIZATION

Education in the proper and efficient utilization of wood has been seriously neglected. It is largely an engineering problem, and yet schools of engineering and of forestry have given this important subject relatively little attention. The growing of the timber crop has been duly emphasized in our professional forestry schools, but relatively little attention has been paid to the conversion, conditioning, and use of the forest crop.

Decisions regarding the use of plywood, lumber, and plastics in our war plants are being made by men untrained and unskilled in the very fundamental principles of wood—even its identification, grading, defects, and technical properties.

Hardwoods vary vitally from the softwoods in texture, structure, and many other properties. Each species (and there are at least 60 commonly used in this country) is different. Although much research has been conducted on wood, it gives promise of still greater developments in the future. A brief review of plastics, plywood, paper, cellulose, and lignin products, and wood in its importance as a source of rubber, fuels, chemicals, preservatives, and explosives indicates the tremendous possibilities of the future. Professional engineering as well as forestry and architectural schools are giving wider recognition to the importance of wood.

We have an excellent laboratory at Madison, Wis. This great laboratory of wood has been emulated, in some respects at least, in Australia, Canada, England, France, and even in Germany. But we should not leave all of our research to one great national laboratory. The problem is too widespread and

(Continued on page 196)

Contributed by the Wood Industries Division and presented at the Fall Meeting, Rochester, N. Y., October 12–14, 1942, of The American Society of Mechanical Engineers.

Principal Characteristics of the Important TEXTILE FIBERS

By WERNER von BERGEN

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TO understand the behavior of textile fibers during the manufacturing processes such as spinning, weaving, finishing, and dyeing, it is essential to know the fundamental characteristics of the fibers involved. These characteristics or properties are best divided into three groups:

1 The microscopical structure.
2 The physical properties.
3 The chemical properties.

The author will limit the discussion of this subject to the most important fibers such as wool, silk, cotton, and rayon, and a few synthetic fibers such as nylon and casein fibers.

Let us first consider the microscopical structure of the animal fibers.

Wool fiber is the hair of the sheep and forms the protective covering of the animal. The ultimate physical limits of wool fibers are series of minute cells of different forms and properties. As seen from the cross section there are either two or three layers of these cells. These layers are named according to their position, i.e., the epidermis or outer layer, the cortex or cortical layer, and the medulla or marrow, Fig. 1.

Epidermis. The epidermis of the fiber is made up of irregular horny cells or scales. They overlap like the shingles of a roof with the free ends projecting outward and pointing toward the tip of the hair, causing the surface of the fiber to present a serrated appearance, Fig. 2.

Cortical Layer. This layer is found below the epidermis scales and constitutes the principal body of the wool fiber. It is made up of slightly flattened and more or less twisted spindlelike cells. These cells are rather closely packed and give the effect of longitudinal striations, which are visible through the epidermis, Fig. 3.

Medulla. In medium and coarse wools, there may be present within the cortical layer the cellular marrow or medulla. In the fine wools, medullated fibers are present only to the extent of 1 in 1000.

The cross-sectional shape varies considerably. The finest fibers are nearly circular, but most fibers show a varying degree of ellipticity. The contour is smooth. The average ratio of

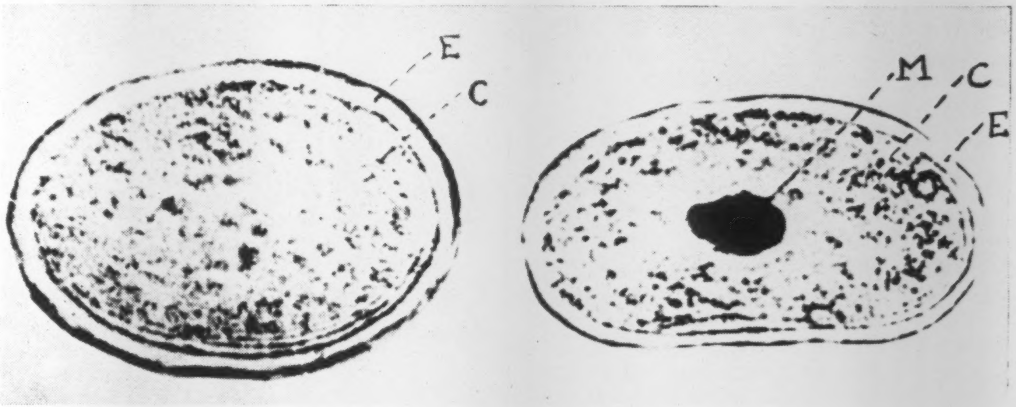


FIG. 1 CROSS SECTION OF HAIR
(*E*, Epidermis; *C*, cortex; *M*, medulla.)

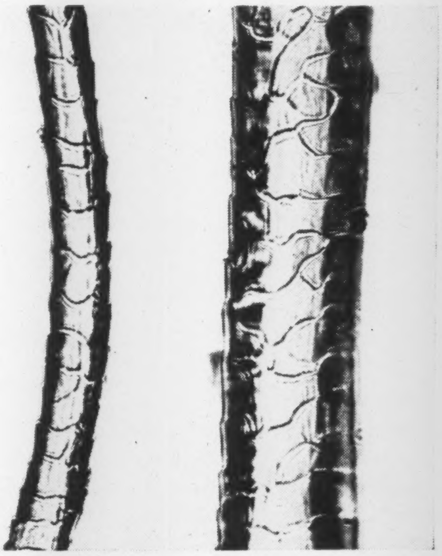


FIG. 2 WOOL FIBER—VARIOUS TYPES OF EPIDERMIS; ×500

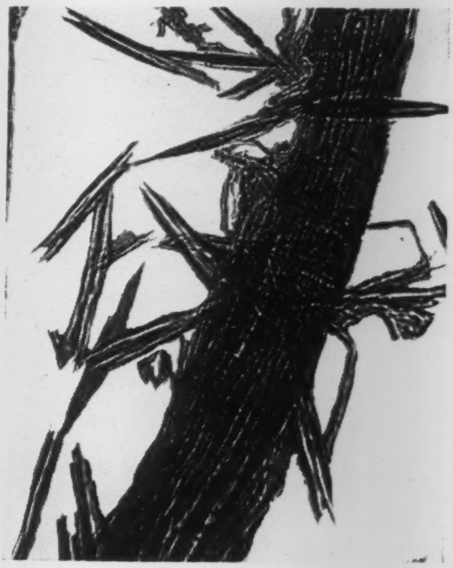


FIG. 3 WOOL FIBER—CORTICAL LAYER AND CELLS; ×500

Contributed by the Textile Division and presented at the Annual Meeting, New York, N. Y., Dec. 1–5, 1941, of The American Society of Mechanical Engineers.

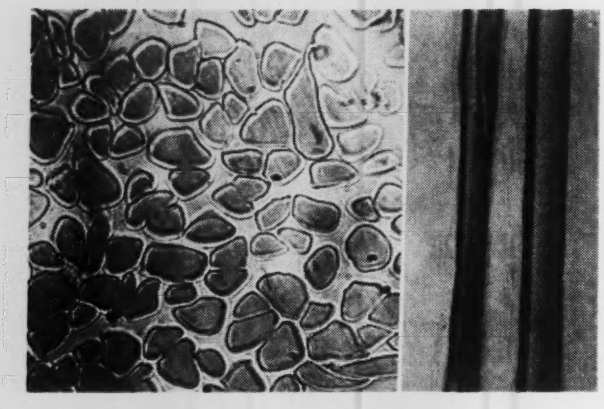


FIG. 4 SILK FIBERS
(Left, cross section; ×500. Right, longitudinal view.)

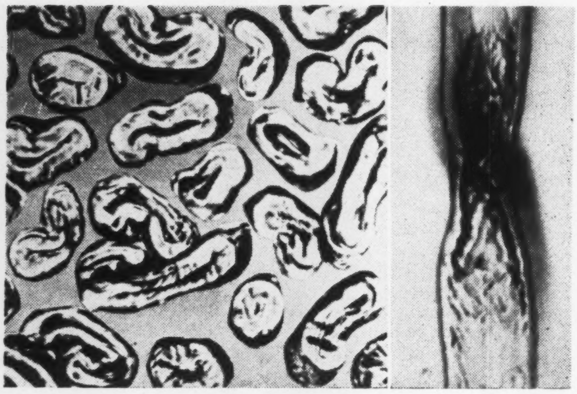


FIG. 6 COTTON FIBERS
(Left, cross section; ×500. Right, longitudinal view.)

the major to the minor axis, known as the contour figure, varies between 1.2 to 1.3.

FORMATION OF SILK FIBER

The general term "silk" refers to the filamentous secretions forming the cocoon of different species of moths. Silk as usually understood is the fiber from the cocoon spun by the larvae of the mulberry silkworm.

In spinning the cocoon the worm secretes a viscous fluid, the fibroin from two tubelike glands in its body. The two tubes join into a common exit in the head of the worm, into which the secretion of two other glands flows, the sericin or silk gum which cements the two fibroin filaments together. Upon emerging from the spinnerets in the head of the worm, the double fiber coagulates on contact with the air.

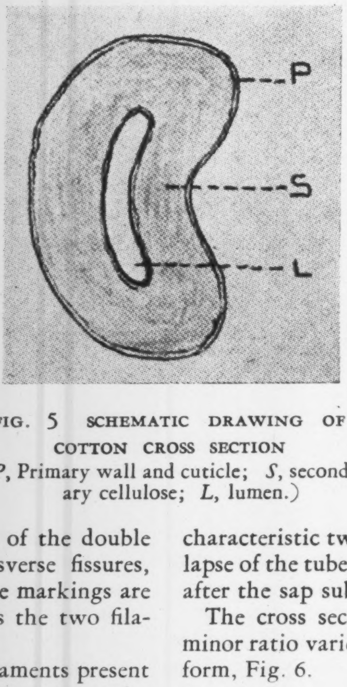


FIG. 5 SCHEMATIC DRAWING OF COTTON CROSS SECTION
(P, Primary wall and cuticle; S, secondary cellulose; L, lumen.)

Microscopical Structure. The surface structure of the double filament is very irregular, consisting of transverse fissures, creases, or folds as well as uneven lumps. These markings are all part of the silk gum or sericin which envelops the two filaments.

When the silk glue is removed, the isolated filaments present a smooth and structureless surface. The filaments are quite regular in diameter, Fig. 4.

The body of the fibers is composed of structural filaments fused into one another in such a homogeneous manner that it is very difficult to recognize them. The common fault in silk called "lousiness" is due to splitting up of the silk filaments into fibrillae or the structural filaments mentioned.

The cross-sectional shape of the silk fiber is the main characteristic for its proper identification. These cross sections are elliptical or triangular in shape with rounded corners, Fig. 4. The contour figure varies from 1.5 to 1.7. Marked differences may be found from a very flat shape like a wedge to a more uniform and rounded shape.

COTTON FIBER

The cotton fiber is a single cellular seed hair of the various species of "Gossipium." As seen from the schematic drawing of the cross section, Fig. 5, the cotton fiber consists of three parts: Primary wall and cuticle, a secondary wall, and the lumen.

The cuticle, the fine film which bears the natural waxes and oils, is closely joined with the primary wall which is a thin film of cellulose produced in the first 20 days of the growth of the fiber.

The secondary wall, the major portion of the cotton fiber, is composed of fibrils spiraling about the axis and making angles up to about 25 deg. These spirals may at intervals change the direction of their inclination from S to Z twist and vice-versa along the fiber length.

As the formation of the secondary layer is produced by the deposition of daily cellulose layers concentrically within the primary wall for about 25 days, this daily precipitation can be brought out as rings similar to the annual rings of trees, which is an indication of the complexity of the cotton-fiber structure.

The lumen is what is left of the hollow part of the fiber through which the seed hair was fed during the growth. The characteristic twist formation of the fibers is caused by the collapse of the tube under the internal strain of the spiral structure, after the sap subsides.

The cross sections have a beanlike shape, and the major-minor ratio varies from 2 to 5, expressing clearly the ribbonlike form, Fig. 6.

RAYON CLASSIFIED BY TYPES

The generic term "rayon" refers to filaments made from various solutions of modified cellulose by pressing or drawing the cellulose solution through an orifice and solidifying it into the form of a filament (A.S.T.M. definition).

Four manufacturing processes are used to produce the following filaments, in the order of their commercial importance:

Viscose Rayon. Filaments composed of regenerated cellulose which have been coagulated or solidified from solutions of cellulose xanthate.

Acetate Rayon. Filaments composed of an acetic ester of cellulose which has coagulated from its solution.

Cuprammonium Rayon. Filaments composed of regenerated cellulose which has been solidified from a solution of cellulose in ammoniacal copper oxide.

Nitro Rayon. Filaments composed of regenerated cellulose solidified from solutions of nitrated cellulose.

Microscopic Appearance. Contrary to silk which is produced in a similar manner, the rayon fibers do not show any structural filaments. They present a homogeneous mass. The microscopical characteristics of the four rayons vary considerably as revealed by examination of their cross sections. The factors responsible for their shape are the nature and strength of the coagulating bath, the size of the orifice, and the difference in the stretching after coagulation. In comparing the four rayon fibers, we find that they vary in their cross sections as follows:

1 Viscose rayon: the cross section has a strongly serrated contour, Fig. 7.

2 Acetate rayon has a kidney or cloverleaf-like shape with smooth and round contours, Fig. 8.

3 Cuprammonium rayon: the cross-section shape varies from a circular to a slightly oval form. The contour is very smooth, Fig. 9.

4 Nitro rayon is similar to acetate rayon, Fig. 10.

Longitudinally the viscose rayon shows a multitude of striations running along the direction of the fiber axis. In acetate rayon the striations are also present but less numerous and more pronounced. The nitro rayon is similar, whereas the cuprammonium rayon only occasionally shows faint striations. The longitudinal striations are directly related to the corrugations along the cross-section contour. The newest "wool-like" viscose fibers have a nearly circular cross section and a contour smooth like wool. Quite frequently, the acetate-rayon-staple fibers, especially, show a twist formation similar to cotton fibers.

In order to subdue or dull the high luster of rayons, metal salts such as titanium dioxide are added to the spinning solution, with the result that the microscope reveals these as pigmented fibers. The amount of pigment present reflects the degree of luster.

PROTEIN FIBERS

The man-made protein fibers refer to filaments or staple fibers made from various solutions of modified proteins similar to the processes used for rayons. Commercially used today are the milk protein, casein, and the soybean protein.

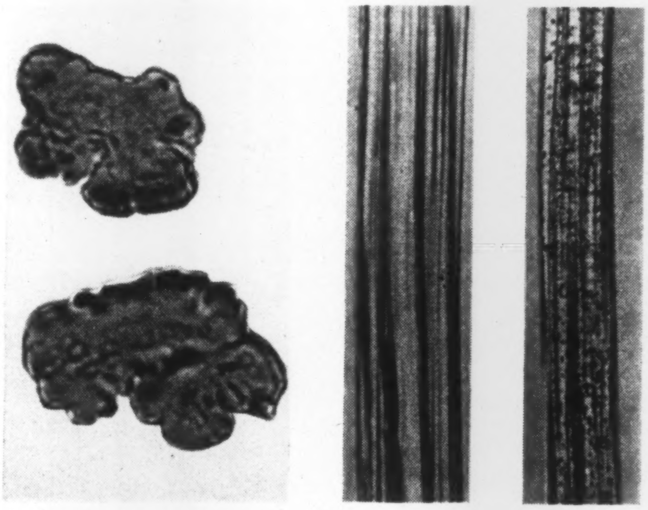


FIG. 7 VISCOSE RAYON
(a, Cross section, bright; ×1000. Longitudinals, b, bright; c, dull; ×500.)

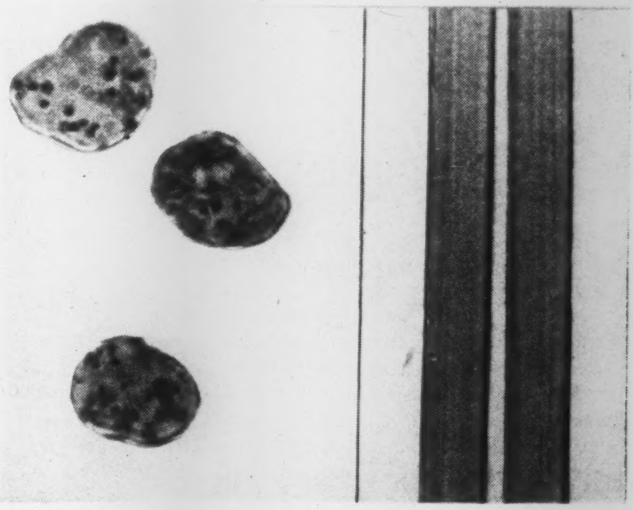


FIG. 9 CUPRAMMONIUM RAYON
(a, Cross section, dull; ×1000. b, Longitudinals, bright; ×500.)

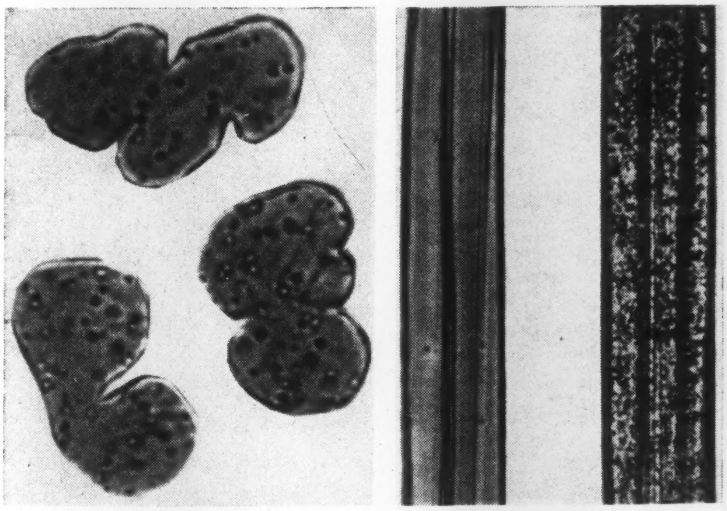


FIG. 8 ACETATE RAYON
(a, Cross section, dull; ×1000. Longitudinals, b, bright; c, dull; ×500.)

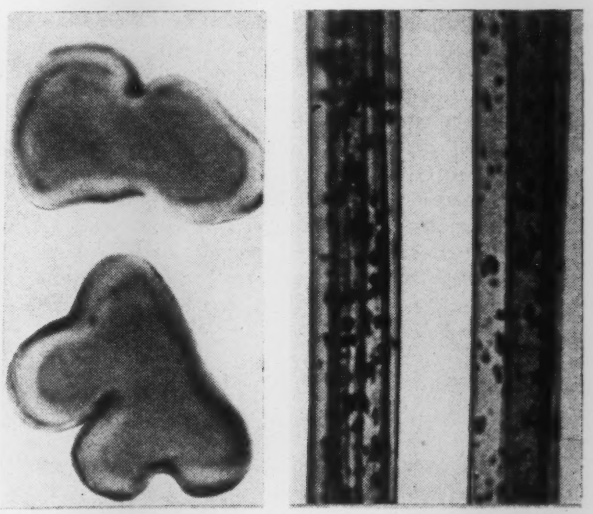


FIG. 10 NITROCELLULOSE RAYON
(a, Cross section, bright; ×1000. b, Longitudinals, dull; ×500.)

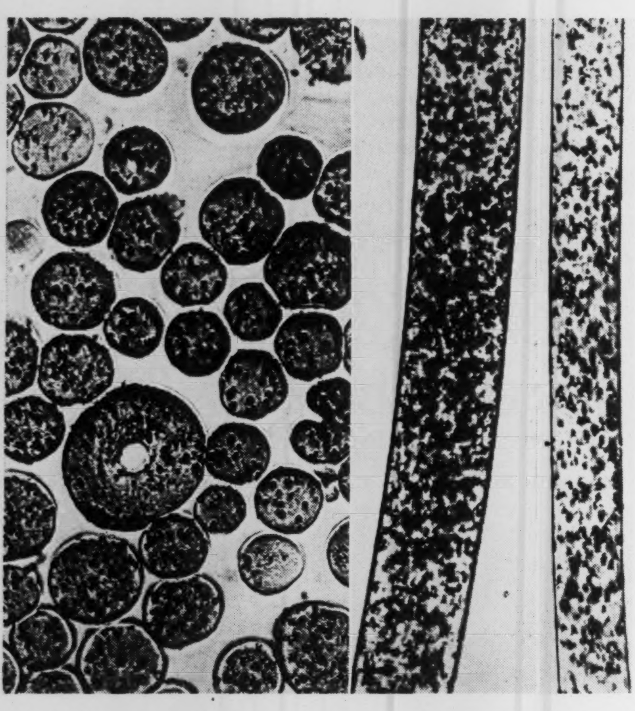


FIG. 11 U. S. CASEIN FIBER KNOWN AS ARALAC, DULL
(*a*, Cross section; ×500. *b*, Longitudinal views; ×500.)

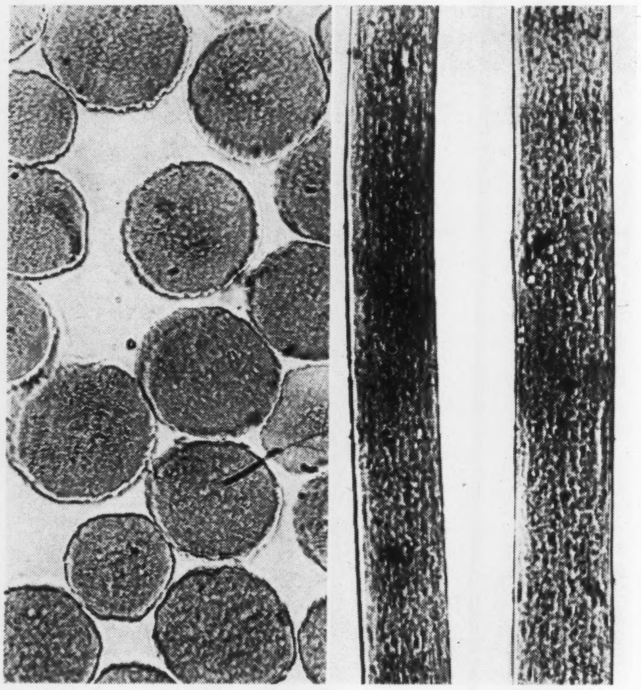


FIG. 12 SOYBEAN FIBERS
(*a*, Cross section; ×500. *b*, Longitudinal views; ×500.)

Probably the most extensive research was made on the possibilities of producing fibers from milk casein. The first fiber of this class produced on a commercial scale originated in Italy. It was introduced in 1935, under the trade name of "Lanital." Today casein fibers are produced commercially in several European countries as well as in the United States and marketed under trade names such as, Lanital (Italy), Aralac (United States of America), Lactofil (Holland), and Tiolan (Germany).

Aralac. In this country various concerns are experimenting with casein fibers. The only fiber produced on a commercial scale at present is Aralac, a product of the Atlantic Research Associates, Inc., which was introduced in the spring of 1940. The fiber is made in two forms, natural and opaque or delustered, Fig. 11.

Soybean Fibers. This fiber was first introduced to the American public at the New York World's Fair in 1939 at the Ford Exhibit. Its base is a protein of the soybean produced by the Drackett Products Company in Cincinnati, under the trade name of Glysol Protein, Fig. 12. All these fibers show the same microscopical characteristics.

Longitudinally the fibers are very even in width showing a slightly rough surface and faint longitudinal streaks. The cross sections are nearly circular and highly uniform. The contour is generally smooth; occasionally small indentations or notches may be observed.

The difference between the natural and the pigmented fibers is very marked.

SYNTHETIC FIBERS

Recently two fibers, nylon and vinyon, have been introduced in the market which can be classified as purely synthetic fibers.

Nylon. The basic principle of the nylon process is the condensation of amino acids through extensive heat-treatment, resulting in a hard, opaque, molten mass. This mass is capable of being spun into a continuous filament similar to the spinning of glass. The microscopical characteristics are as follows.

The filaments appear very even in their width over the whole length and smooth like a glass rod showing no surface structure at all and no sign of any twist. The cross section is circular, the contour absolutely smooth. The fibers are produced in bright as well as dull form, which is revealed through the presence or absence of pigments, Fig. 13.

Vinyon. Vinyon is produced by a polarization of vinol chloride and vinol acetate. The raw polymer in the form of a white powder is dispersed in acetone and the dope obtained in this solution is spun in the same manner as acetate rayon and coagulated by the dry or warm-air process.

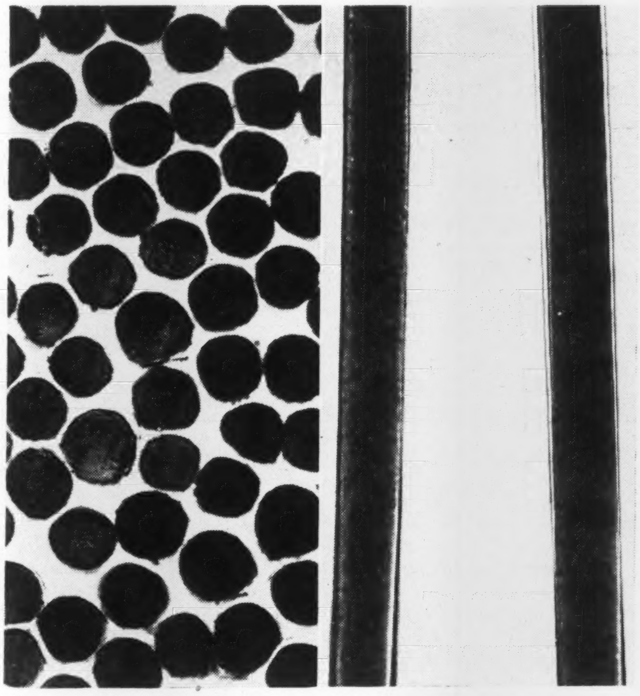
When viewed under the microscope longitudinally, the fiber is smooth with a lumenlike channel running through the middle of the fiber with occasional twist. The illusion of a lumen is caused by the peculiar dumbbell-like shape of the cross section, Fig. 14.

PHYSICAL CHARACTERISTICS

The physical characteristics of the textile fibers vary within wide limits. When the quality of a textile fiber is expressed, the term "quality" includes not only one characteristic but a number of them. For example, the main characteristics which have a decisive influence on the quality of wool are fineness, length, and strength in the rotation of their importance. In cotton, the picture is slightly reversed, with length as the dominating factor, then fineness and strength. For all important fibers, we can generally agree that these three properties, namely, fineness, length, and strength are of ultimate importance.

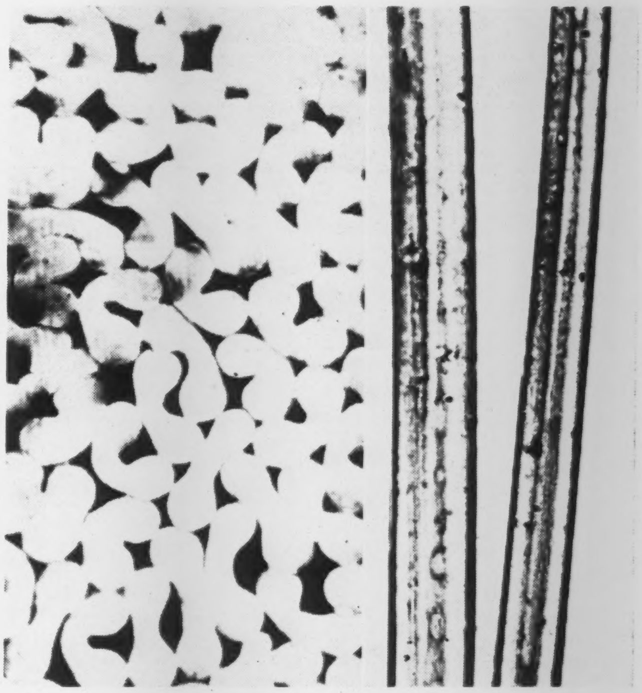
Fineness. The fineness of the fibers is expressed either in microns (1/1000 mm) or in fractions of an inch. In the woolen industry the term "micron" is generally accepted.

The fineness is established by measuring the width or the cross section of the fiber. Both methods are based on the projection of the image of the fiber at 500 magnification, through a microscope on a wedge ruler, or measuring the image by means



(*a*) (*b*)

FIG. 13 NYLON: BRIGHT, DYED
(*a*, Cross section; ×500. *b*, Longitudinals; ×500.)



(*a*) (*b*)

FIG. 14 VINYON
(*a*, Cross section; ×500. *b*, Longitudinals, bright; ×500.)

of a bidiameter scale, or a planimeter. The width of the image of the fiber is best recorded directly on a wedge ruler. The details of these methods may be found in the American Society for Testing Materials Manual, under the designations of D 419-37 and D 472-41.

The most suitable microscope for this work is the Bausch & Lomb VH fiber-measuring apparatus. The newest model of this instrument is shown in Fig. 15.

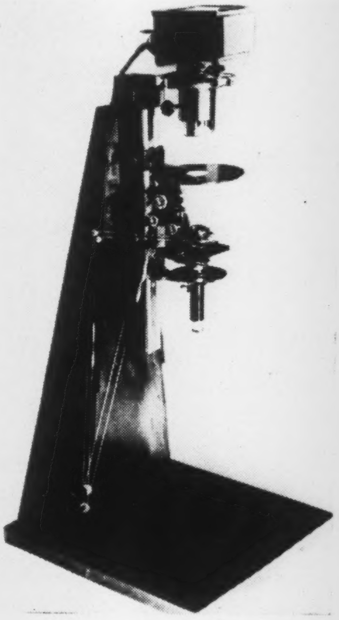


FIG. 15 BAUSCH & LOMB V H FIBER-MEASURING APPARATUS

By using this method, which is a standard method of the American Society for Testing Materials, to establish the fineness of various textile fibers, the results in Table 1 were obtained.

As this scale was worked out for use in woolen mills, the whole range of wool grades is shown as they are used in the marketing as well as manufacturing processes. Added features are the recording of the fineness of specialty hair fibers, such as mohair, cashmere, camel hair, alpaca, and vicuna, as well as measurements on secondary raw material, such as cotton, silk, and rayon, which are extensively used in the woolen industry. This table indicates that the finest wool quality, 80's, has an average width of 19 microns and the coarsest wool quality, 36's, a width of 40 microns.

The finest specialty hair fiber, vicuna, has an average fineness range between 13 and 14 microns. Silk measures between 9 and 11 microns, based on the individual filaments; cotton from 16 microns for the best grades and up to 21 microns for the coarsest grade, which indicates that cotton fibers as a whole are considerably finer than most wool fibers. The position of the rayon fibers on the scale is according to their denier size. Each denier size corresponds to a certain micron size. For example, the average width of a 3-denier viscose rayon will fall between 19 and 21 microns, whereas a 10-denier rayon will measure from 35 to 38 microns.

Of high importance is the variability of the individual fibers making up this average. We find that the natural fibers show a coefficient of variation from 18 per cent upward, whereas the man-made fibers are below this figure and, therefore, more uniform.

The most uniform fiber the author has noted thus far is nylon. It has a variation between 5 and 6 per cent, whereas viscose and acetate staple fibers normally show a variation from 11 to 15 per cent. For example, the dispersion range for wool fibers, viscose rayon, staple fibers, and nylon, having the same average width of 20 microns, is as follows:

	Average micron	Standard deviation micron	Dispersion range 3×, standard deviation
Wool......	20	4.0	8–32 Microns
Viscose....	20	2.3	13–27 Microns
Nylon.....	20	1.25	16–24 Microns

Length. Natural fibers occur in a great variety of lengths. The length of wool fibers varies from less than 1 in. up to 15 in.; cotton fibers from less than $^1/_2$ in. up to $2^1/_2$ in. The silk filaments, as produced by the silkworm, are continuous threads from 600 to 1000 yards in length; while, on the other hand, the man-made fibers, such as rayons and nylons, can be produced in any length which is desired.

The continuous rayons are known as rayon filaments, whereas

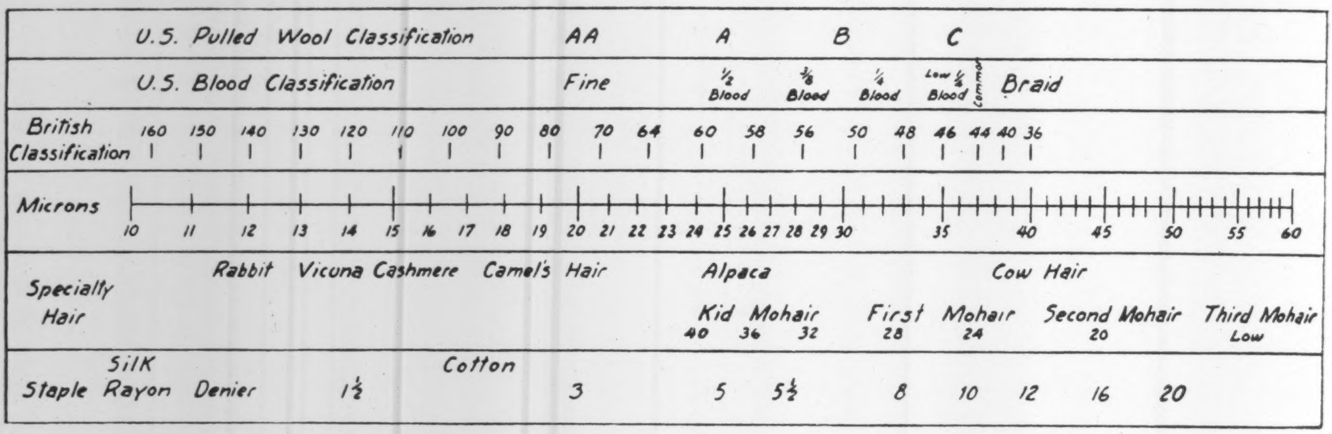

U.S. Pulled Wool Classification
AA
A
B
C
U.S. Blood Classification
Fine
1/2 Blood
3/8 Blood
1/4 Blood
Low 1/4 Blood
Common
Braid
British Classification
160 150 140 130 120 110 100 90 80 70 64 60 58 56 50 48 46 44 40 36
Microns
10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 35 40 45 50 55 60
Specialty Hair
Rabbit
Vicuna
Cashmere
Camel's Hair
Alpaca
Cow Hair
Kid Mohair
40 36 32
First Mohair
28 24
Second Mohair
20
Third Mohair
Low
Silk
Staple Rayon Denier
1½
Cotton
3
5
5½
8
10
12
16
20

TABLE 1 COMPARATIVE SCALE FOR FINENESS OF VARIOUS TEXTILE FIBERS

(Courtesy of Forstmann Woolen Company Laboratory)

AVERAGE WIDTH RANGES FOR VARIOUS FIBERS[a]

1 WOOL TOP, U.S. AND A.S.T.M. STANDARD

	Grade	Fineness range, microns
Fine	80's	18.1 to 19.5
	70's	19.6 to 21.0
	64's	21.1 to 22.5
$^1/_2$ Blood	62's	22.6 to 24.0
	60's	24.1 to 25.5
	58's	25.6 to 27.0
$^3/_8$ Blood	56's	27.1 to 29.0
$^1/_4$ Blood	50's	29.1 to 31.5
	48's	31.6 to 33.2
Low $^1/_4$ Blood	46's	33.3 to 34.7
Common	44's	34.8 to 36.5
Braid	40's	36.6 to 38.7
	36's	38.8 to 41.3

2 RAYON

	Fineness range, microns
$1^1/_2$ Denier	14.0 to 15.0
3 Denier	19.0 to 21.0
5 Denier	24.0 to 26.0
10 Denier	35.0 to 38.0

3 MOHAIR

	Fineness range, microns
Kid	24.0 to 30.0
First	30.0 to 40.0
Second	40.0 to 50.0
Third	50.0 to 60.0

4 SPECIALTY HAIR AND MISCELLANEOUS FIBERS

	Fineness range, microns
Rabbit	12.0 to 15.0
Vicuna	13.0 to 14.0
Cashmere	15.0 to 16.0
Camel hair, fine	17.0 to 20.0
Alpaca	25.0 to 29.0
Silk	9.0 to 11.0
Cotton	16.0 to 20.0

[a] All results were obtained by the width method as described in the Standard Methods of Test for Fineness of Wool (D 419–37) and the Tentative Specifications and Methods of Test for Fineness of Wool Tops (D 472–40 T) of the American Society for Testing Materials (see pp. 215 and 219.)

the rayon-staple fibers are the same filaments cut to $^1/_2$ to 2-in. lengths for the cotton industry, and from $1^1/_2$ to 5 in. or more for the woolen industry.

The length variation within the individual staples is quite small; it may be less than 10 per cent, but this variation, however, is greatly increased through breakages in manufacturing processes.

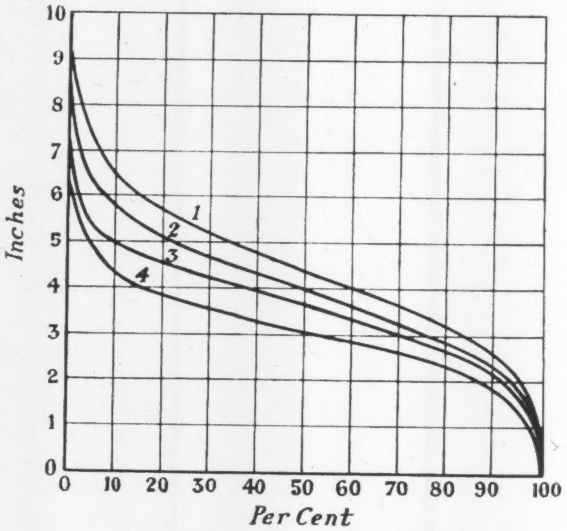
The length variation for wool and cotton tops, for example, runs 30 per cent and over, whereas for rayon tops, 20 per cent and over. Fig. 16 illustrates this variation in four wool tops on the basis on their staple-fiber diagrams.

Strength. When compared with metals, the average breaking strength of textile fibers is astonishingly high.

In Table 2,[1] the elastic constants for various fibers and metals are put together, giving the modulus of elasticity, the average breaking strength, and the elongation at break.

Wool, based on the breaking strength, is the weakest fiber and has about the same strength as rolled aluminum, but it is the most elastic. Silk follows, and then cotton. As the elasticity decreases, the breaking strength increases. Cotton and silk have a breaking strength equal to that of an average steel wire.

The rayon fibers hold a middle position, depending upon whether they are of the unoriented or oriented type. With increased orientation of the micelles, the breaking strength and modulus of elasticity increase.



(1) 48's Top av. length 5.1 in... ±1.6
(2) 50's Top av. length 4.1 in... ±1.4
(3) 56's Top av. length 3.7 in... ±1.1
(4) 62's Top av. length 3.1 in... ±1.0

FIG. 16 LENGTH VARIATION IN FOUR WOOL TOPS

A further illustration of the different elasticity properties of various fibers is given by the stress-strain curves of Houwink.[2] Fig. 17 gives a stress-strain curve for rubber, wool, viscose,

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[1] The data in Table 2 on the textile fibers were supplied by Dr. Harris, National Bureau of Standards. The data on metals was taken from the "Handbook of Chemistry and Physics," Twenty-first edition, Chemical Rubber Publishing Company, Cleveland, Ohio, 1936.

[2] "Elasticity, Plasticity, and Structure of Matter," by R. Houwink, Cambridge University Press, London, England, 1937, pp. 283–284.

TABLE 2 ELASTIC CONSTANTS FOR VARIOUS FIBERS AND METALS

Material	Modulus of elasticity, psi × 10^6	Average breaking strength, psi	Elongation at break, per cent
Wool	Dry 0.16	17000– 25000	30–50
	Wet 0.16		50–60
Silk	1.4	45000– 74000	20
Cotton	7.1	40000–111000	5
Viscose rayon	Unoriented 0.7	31000– 88000	40
	Oriented 7		7
Acetate rayon	Unoriented 0.7	23000–111000	20
	Oriented 7		6
Nylon	Oriented 7.2	72000–100000	30–10
Aluminum rolled, 99.5	9.7–10	16000– 21000	...
Copper wire, hard	14.5–17	49000– 67000	...
Steel wire	27.88	50000– 80000	...

TABLE 3 RELATIVE WET BREAKING STRENGTH OF VARIOUS YARNS[a]

Yarn	Wet strength in per cent of dry strength	Strength change through wetting out, (+) = increase, per cent (—) = decrease, per cent
Cotton	110–130	+10 +30
Wool	80– 90	—10 —20
Silk	75– 85	—15 —25
Nylon[b]	About 85	—15
Viscose rayon, normal	35– 60	—40 —65
Viscose rayon, high strength	About 70	—30
Acetate rayon, normal	55– 70	—30 —45

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[a] "Fehler in Textilien," *Melliand Textilberichte*, Heidelberg, 1938.

[b] Nylon and Its Identification," by W. von Bergen, *Rayon Textile Monthly*, vol. 20, 1939, pp. 17–21.

TABLE 4 MOISTURE REGAINS OF VARIOUS TEXTILE FIBERS[a]

Equilibrium being approached from wet side
Temperature = 21 C
Relative humidity = 65 per cent

Material	Regain, per cent
Carpet wool	16.7
Clothing wool	16.1
Viscose rayon	15.6
Cuprammonium rayon	15.2
Raw silk	12.8
Degummed silk	11.1
Mercerized cotton	10.8
Raw cotton	9.0
Purified cotton	8.9
Acetate rayon	8.4
Nylon[b]	About 4.1

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[a] J. G. Wiegerink, National Bureau of Standards, 1938.

[b] E. I. du Pont de Nemours, Inc., Nylon Division.

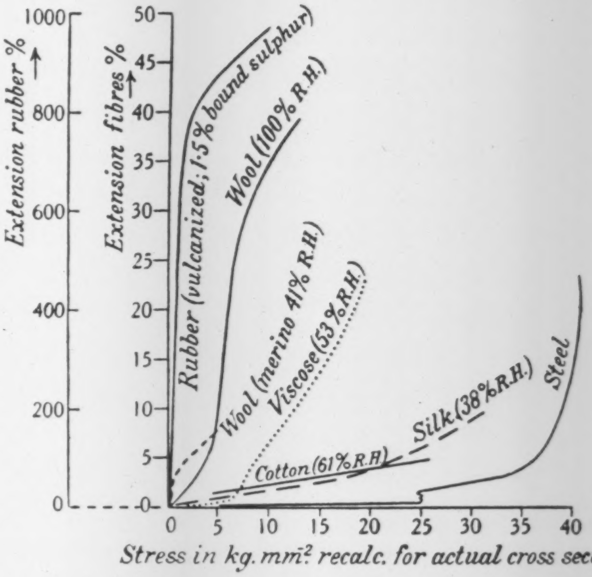

FIG. 17 STRESS-STRAIN CURVES FOR VARIOUS MATERIALS
(Stresses calculated for the actual area during test.)

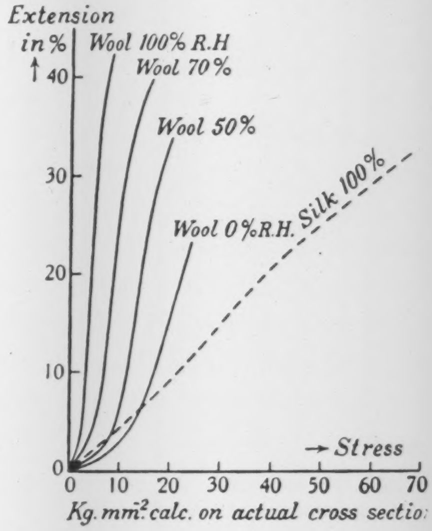

FIG. 18 STRESS-STRAIN CURVES FOR SEVERAL PROTEIN FIBERS UNDER VARIOUS CONDITIONS

cotton, silk, and steel, revealing their differences in the shapes of these curves.

Fig. 18, S-shaped stress-strain curves for wool and silk are shown recorded under various conditions. In general, a short flat portion is observed at the beginning, then the curve becomes steeper until a second change in direction is reached. The figure shows further that moisture has a large influence on the form of the wool curve, whereas in silk the influence is not so considerable.

Inasmuch as in the manufacturing of textile fabrics, the fabrics have to go through numerous wet processes, it is essential to know the breaking strength of the fibers or the yarn in the wet state. Table 3 gives this information. From the table we see that cotton actually increases in strength from 10 to 30 per cent through wetting out. Wool loses 10 to 20 per cent, silk 15 to 25 per cent, nylon 15 per cent, and some of the rayons up to 65 per cent.

Moisture Regain of Various Textile Fibers. Probably one of the best known physical characteristics of textile fibers is their ability to hold a certain percentage of moisture. The amount of water present in textile fibers varies according to the temperature and relative humidity, and it varies considerably between the various fibers.

Table 4 shows the regain percentage as established by Mr. Wiegerink (National Bureau of Standards), in his drying research assignment.

When approached from the wet side, the wool fiber shows the highest moisture regain. Viscose and cuprammonium rayon follow, then silk, cotton, acetate rayon, and nylon, respectively.

Specific Gravity. The specific gravity or density of the fibers, as seen in Table 5, varies, nylon being the lightest fiber, followed by silk and wool, with cotton and viscose rayon considerably heavier.

Chemical Properties. In their chemical properties, the fibers vary just as much as they do in their physical properties.

The chemical behavior of a fiber is naturally in direct relationship to the chemical compounds of which the fiber is made. The protein fibers such as wool and silk generally show a good resistance to all acids as they are applied for commercial purposes, whereas they are quite sensitive to alkalies.

TABLE 6 CHEMICAL PROPERTIES OF VARIOUS TEXTILE FIBERS

Fiber	Wool	Silk	Cotton	Viscose rayon	Acetate rayon	Casein	Nylon
Substance	Protein	Protein	Cellulose	Cellulose regenerated	Cellulose acetate	Protein regenerated	Amino acid polymer
Components	C,O,H,N,S	C,O,H,N	C,O,H	C,O, H,	C,O,H	C,O,H, N,S,P	C,O,H,N
Combustibility	Nil	Nil	Yes	Yes	Nil	Nil	Nil
Per cent swelling:							
Water	10	....	10	<30	>10	11	Nil
N/10 Caustic soda	>20	....	>20	....	....	35	Nil
Resistance to acids, 212 F:							
Organic (pH4–6)	Very good	Very good	Very good	Very good	Very good	Very good	Very good
Sulphuric (pH2–3)	Very good	Fair	Poor	Poor	Poor	Fair	Good
Sulphuric, 4 per cent dry	Very good	Poor	Destroyed	Destroyed	Destroyed	Fair	Fair
Resistance to alkalies:							
Soda (pH 11) 125 F	Good	Very good	Very good	Very good	....	Good	Very good
Soda (pH 11) 212 F	Poor	Good	Very good	Very good	....	Fair	Very good
5 Per cent caustic soda, 212 F	Dissolved	Dissolved	Good	Fair	....	Dissolved	Good

TABLE 5 SPECIFIC GRAVITY OF FIBERS

Silk (raw)	1.33
Silk (boiled off)	1.25
Nitrocellulose rayon	1.54
Cuprammonium rayon	1.52
Acetate rayon	1.33
Viscose rayon	1.52
Wool	1.32
Cotton, hemp, and jute	1.48
Linen	1.50
Ramie	1.51
Tussah silk	1.27
Nylon	1.14

Cellulose fibers such as cotton and rayons have a lower resistance toward strong acids, but a very high resistance toward alkalies.

In Table 6, an attempt has been made to illustrate the main chemical behavior of the various fibers. The table brings out the facts mentioned, that the wool substance has a high resistance toward acids even when boiled, and a low resistance toward strong alkalies. Cotton and regenerated cellulose fibers have a poor resistance toward strong acids, quite good resistance toward organic acids, and an excellent resistance toward strong alkalies. The behavior of the silk fiber places this fiber between wool and cotton. Nylon fibers show the highest resistance of all fibers to chemical agents.

MANUFACTURING PROCESSES

The questions before us now are, how do these properties influence the manufacturing processes, and to what extent do they affect the final product?

The microscopical structure of the fibers directly indicates the strength and elastic properties of fibers. The wool fiber owes its rubberlike elastic property to the structure of the cortical layer. The cortical cells are able to expand and contract in a telescopic manner, the epidermis taking part in a similar way. Higher or lower luster of wool fabric may be influenced by the number of scales present over a certain standard length of the fiber. With a lower number of scales more light is reflected, resulting in a higher luster.

The physical properties play the most prominent part in such processes as spinning, weaving, and finishing. For example, the fineness directly affects the size of the yarn which can be spun. It governs the spinning limits, e.g., the finer the fiber, the finer the yarn that can be spun from it. For this reason, the wool grades were originally designated on the basis of the possible spinning count.

The fineness of the fibers used will be directly reflected in the touch and the softness of the finished fabric. The finer the fibers, the softer the fabric and, conversely, the coarser the fibers, the harsher and stiffer the fabric.

In the same manner the length of the fiber has an influence on the count limits. It is quite well known that the longer and more uniform the fibers are, the stronger and better will be the spun yarn. That the trade is recognizing this quality is proved by the fact that the fine long wools, as well as the long fine cotton fibers, bring a premium. A good yarn will in turn produce a high weaving efficiency and the finisher will be able to produce a better fabric. In order to produce a variety of fabrics, in a woolen mill, it is essential that the spinner and the designer in co-operation with the finisher select the best suitable type of wool for each individual fabric type. For example, to produce a fine tropical worsted a long fine fiber is necessary, and in the instance of a men's wear overcoating, a combination of fine, short fibers will produce the most beautiful effect.

The chemical properties have to be closely guarded in the manufacturing processes, such as scouring, dyeing, carbonizing, silk weighting, mercerizing, and drying to avoid damage.

In raw-wool scouring, the pH is about 11, with the temperature at 125 F, and with a treatment time less than fifteen minutes. Whereas, in kier boiling of cotton, the pH of the liquor may vary from 11–14 at boiling temperature with a process time from 2 to 14 hours.

In the dyeing process, most wool is dyed at a pH ranging from 2 to 5, with the liquor kept at boiling temperature from 2 to 5 hours, whereas many of the cotton dyes such as sulphur and direct dyes are applied in a 200 F bath at a pH of 11 or higher with a dyeing time of about one hour. Where both fibers are combined, liquor must be kept at a pH range of between 4 and 9.

In carbonizing, which is a process of burning out vegetable matter in wool by chemical means, sulphuric acid is used. Its strength must be kept within close limits. The lower limit at which the vegetable matter is still destroyed is produced with an acid concentration in the cloth of about 3 per cent. The upper limit is set by the possible damaging effect on the wool fiber itself, which is about 6 per cent sulphuric acid.

Example after example could be given. They all indicate that with the proper knowledge of the fundamental property of the fiber involved, the millman should be able to produce an end product that is not only beautiful but has the best possible wearing properties through the preservation of the fibers.

It is up to us engineers and chemists to assist the millman with our intimate knowledge of the factors involved to achieve this goal. From the author's experience in the woolen and worsted industry, it can be stated that we still have far to go and need a tremendous amount of additional information in order to iron out all the "headaches" which are presenting themselves daily. Never in 22 years' connection with the woolen industry has the author felt so much the lack of knowledge as today when the industry is required to produce quality goods on a mass-production basis.

Planned
CONSERVATION *of* MANPOWER

In the Equipment Department of the New York Central

By F. K. MITCHELL

ASSISTANT GENERAL SUPERINTENDENT, MOTIVE POWER AND ROLLING STOCK, NEW YORK CENTRAL SYSTEM

MILITARY conflicts, similar to the one in which we are now engaged, are won by that side having the most adequate personnel. Personnel, or manpower as we term it, is made adequate by reason of its sufficiency in numbers, training, clothing, material, and transportation. This statement applies to the personnel of our armed forces and to the personnel of industry as well. The latter must be maintained, even though there is a constant drain to the military services.

Transportation, to be adequate, must be capable of handling peak movements of men, both during training and for actual combat, without interruption. Further, it must be capable of handling, without interruption, peak movements of raw materials to the factories and munitions plants, and likewise of the finished products (clothing, food, and material) to the point of consumption. This can only be accomplished by adequate personnel within the transportation industry, of which our rail systems are the heart, the arteries, and the veins.

These facts were impressed upon us during the first world war. They have since been recognized by military, political, industrial, labor, and transportation leaders. That recognition is responsible, in a large measure, for the successes so far achieved.

RAILWAY MANPOWER PREPARED FOR EMERGENCIES OF WAR

It may be well to review in a general way what forward steps toward the conservation of manpower were accomplished by the American rail transportation systems between the Treaty of Versailles and the "mistreaty" of Pearl Harbor. While it may be said that, on that eventful day, at least some of our military forces were not alert to the situation, it cannot be said that either the military engineer forces or the rail transportation systems have not been alert to the fact that just such a situation as we are now facing might someday become a grim fact.

It is no secret now that, years before Pearl Harbor, railroads all over the country, at the behest of the military authorities, sponsored and furnished reserve commissioned engineer personnel for Railway Headquarters, operating, and shop battalions. These men, together with their military instructors, studied, among many other problems, those incident to just such a troop movement as took place to the West Coast shortly after December 7, 1941. Pertinent facts as to routes, alternate routes, traffic densities, equipment needs and availability, concentration, and loading points, etc. were developed and made available to our military authorities. All data so developed, every experience so gained, has had its favorable effect in the conservation of manpower.

It is also no secret now that the transportation difficulties of 1917 and 1918 have been made a study by railroad management, the Association of American Railroads, and various Governmental agencies, with the express purpose of correcting them under such conditions as are now prevalent. Congested areas, bottlenecks, misuse of cars, equipment failures, and every other adverse circumstance have been considered and remedial action taken. The lessons of the first world war have provided the answers so far to many of the problems of the present war. Every corrective measure worked out and put into effect is now making our available manpower more adequate.

This has been called an "Engineers' War." Let us see what the engineer and equipment-department official had contributed toward manpower conservation in the rail transportation field even before this war began.

ADVANCES ON THE RAIL-EQUIPMENT FRONT

In the design of equipment, outstanding examples can be found. The use of alloy steels in the manufacture of cars, locomotive boilers, rods, valve-gear parts, and appurtenances had not only reduced the weight of these parts but materially increased their life and minimized the maintenance requirements. Scientific water treatment and the introduction of dissolved-solids control had minimized boiler troubles and reduced the frequency of boiler washing. In 1917 and 1918, leaky boilers and fireboxes constituted one of the greatest sources of trouble and required many thousands of man-hours to be expended. Boiler washing was formerly necessary on the average of every three to five days, thereby using up many thousands more of valuable man-hours. At the beginning of this war, boiler troubles, except in the very worst water districts, were one of our minor problems. Locomotives are now run fifteen to thirty days before washing becomes necessary. Grate troubles, requiring huge stocks of replacement parts and many men to maintain them during the earlier war, have been made negligible by the design and use of finger-type grate. The use of roller bearings on driving boxes, rods, engine truck, trailer, tender, and car journals had materially conserved the manpower formerly required to maintain the parts they replaced. The introduction of integral cast-steel engine beds and cylinders likewise has decidedly reduced the man-hours necessary to maintain the present-day locomotive, as well as made it more serviceable. Similar results had come through the use of cast-steel bolsters and side frames on cars and tenders. Improved draft gears and shock absorbers had proved their worth in reducing maintenance of passenger- and freight-equipment cars, an effect which is readily equated to minimize manpower requirements.

In locomotive and car shops, the replacement of old methods and machinery had kept abreast of the engineering progress in machine and tool design. Labor-saving devices came into use as fast as the combined effort of railroad and industrial engineers could conceive them and prove their worth. The same was true in engine-terminal and car-repair yards. Here also, drop tables for handling wheels, and even entire trucks, replaced old

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hydraulic and manually operated jacks. Boom and other types of portable trucks replaced manual handling of a myriad of parts. Pneumatic and electric tools replaced hand tools. Duplicators replaced layout and punching of individual steel sheets. Spray painting replaced the brush. Welding replaced renewal. In the switching yards, car retarders speeded up the classification and switching of freight cars. On the line, improved color-light signals, train control, remote control of switches, and improved track and bridge construction had speeded up train movements, and all this with greater safety. All these things, and many more, the engineer contributed toward making the railroads ready for the present emergency. Candidly, had it not been for that contribution, there is little doubt that the manpower, which was available on December 7, 1941, would have been woefully inadequate.

While these engineering developments were in progress, the maintenance of equipment departments not only were co-operating but at the same time were engaged in another sort of manpower conservation. They had seen during the previous war that there were too many shops, engine terminals, and repair facilities. They recognized that in this fact lay a potential waste of manpower, both of managerial talent and of workmen. They further recognized that the improvement which engineering effort was making in motive power and rolling stock was rapidly increasing its availability and reducing its need for being cut out for repairs. Accordingly, they set about reducing the number of such facilities to the actual requirements. In a large measure this was accomplished through co-operative agreements between management and labor. Today, although in some instances the number of shops and repair facilities in use on a particular railroad has been reduced as much as 50 per cent, those remaining are wholly adequate for their task. At the same time had this not been done the manpower reservoir would have been drained just that much more.

TABLE 1 .COMPARISON OF RAILROAD OPERATIONS IN 1918 AND 1941

For all Class 1 American railroads	Year 1918	Year 1941	Per cent of increase or decrease
Net ton-miles produced (1000).....	440,001,714	513,145,553	+16.6
Revenue passenger-miles (1000)....	42,676,579	29,350,229	—31.2
Average equipment-department employees........................	425,281	315,851	—25.7

The foregoing discussion has in a general way outlined the prewar manpower conservation efforts of the railroads. The results are reflected in the figures given in Table 1.

What has been said about the prewar manpower situation on the American railroads in general is representative of what also occurred on the New York Central Lines. The wartime manpower situation in the Equipment Department of the New York Central Lines can, it is believed, be considered representative of the situation in that department for most of the nation's railroads.

MANPOWER SITUATION IN EQUIPMENT DEPARTMENT OF NEW YORK CENTRAL

At the outset of this war, or specifically, as of January 1, 1941, the Equipment Department of the New York Central Lines employed 26,117 men. Of this total, 16,922 were those coming under the classification of "skilled," including mechanics, helpers, and apprentices. There were some furloughed employees in all crafts or classifications, but in most instances the number was so few that before many weeks had elapsed those available for recall to service were either nonexistent or at least entirely inadequate to meet the demands of a rapidly growing business. When this situation developed, those responsible immediately set about devising and instituting measures designed to improve it.

The action taken was of three general classifications, i.e.: (1) That accomplished through federal and state government-management co-operation; (2) that accomplished through management-labor co-operation, and (3) that accomplished primarily through the efforts of management.

In the first group came a closer co-operation with federal hiring agencies. All over the entire System the local representatives of the United States Employment Service and the Railraod Retirement Board Employment Service were contacted and kept advised of our needs. The possibilities of assistance from them were exhausted before any other channels of employment were used. These agencies thus have been used in the effort to keep our employment abreast of our needs.

In order to improve and make more effective those employees already in service, educational and training programs sponsored by national and state agencies have been instituted. As of November 1, 1942, equipment department employees, numbering 1512, were enrolled in job-instruction courses and 1411 employees, in foremanship-training courses sponsored by national and state agencies, and universities.

In our endeavor to avoid losing to the draft much-needed employees, and still comply with the provisions and intent of the Selective Service Act, we have co-operated both nationally and locally with the officials charged with the administration of that act. We have asked for deferments only where the act permitted and circumstances justified such requests. In the main, we have found local and national officials most sympathetic to our needs. On the other hand, certain features of the administration of the act have affected us adversely. These will be discussed later.

To help further the national endeavor to solve the railroad manpower problem, we have been furnishing a member for the Manpower Advisory Committee of the Office of Defense Transportation and likewise for the Regional Mechanical Committee of that same office.

The second group of activities which involved management-labor co-operation have been quite varied. Early it was recognized by both parties that certain provisions in our labor contracts would have to be temporarily waived or amended in order to meet the emergency. One of these affected the possibility of expanding the ranks of our mechanics. Under the contract, only mechanics with 4 years' experience could be hired as such, and only after completing a 4-year apprenticeship could a man be made a mechanic. Negotiations between management and labor led to an agreement whereunder apprentices can be advanced to the rank of mechanic after completing 2 years of their apprenticeship, and helpers with at least 2 years' experience can be advanced to mechanics. This same understanding also provides how the seniority of men so advanced shall be established.

Other understandings made possible an adjustment of certain limitations on hiring ages, some easing of physical requirements for hiring, and the removal from the labor contracts of certain inhibitions as to race and color. Management-labor conferences have likewise been held on questions of securing needed help, reducing absenteeism, wage and working conditions, the employment of women, more intensive participation of employees in safety activities, and improved methods of handling controversial matters and avoiding them. These activities have aided our conservation-of-manpower program very materially.

The third group of manpower-conservation activities, conducted primarily on the part of management, have likewise been very effective.

Realizing that every hour lost through accident or sickness meant some vital task either left undone or only superficially done, activities along these lines have been ceaseless. Hazards of all sorts are continually being sought and eliminated. Shop-safety control boards, consisting of workmen and functioning not only as safety committees but also as judge and jury in safety-rule-violation cases, have been instituted. Additions have been made to nursing staffs, and improved medical attention provided. Supervisors and workmen alike have been encouraged to take advantage of Red Cross first-aid instructions, and hundreds have done so. The annual physical examination of supervisors has been made mandatory. Salt tablets have been made available to all during hot weather. Toilet and washroom facilities have been improved where material for such work could be obtained. Ventilation of welding and other shops has been improved by exhausters and fans where these were obtainable, and similar improvements are to be made if and when authorization for the material can be obtained. Certain engine terminals are having stalls lengthened, and shops are being improved in order that men may be better housed during cold weather. Other improvements of the same nature are to be made when authorization can be had for the needed materials. All of these measures will doubtless have their beneficial effect in our manpower-conservation efforts.

REHABILITATING AND MODERNIZING MACHINE TOOLS

The transfer of the machinery from shops previously closed to other shops has to some extent helped to relieve an acute shortage of machine tools. To offset further this shortage, and at the same time keep available machinery in the best possible condition, a central machine-tool repair shop was set up. Although very few new machine tools have been or can yet be purchased, the programming of existing tools through this shop for reconditioning and modernizing has been progressing quite satisfactorily and has given us the equivalent of 41 new ones.

While this process has been going on and materially aiding in making our existing manpower more effective, another program of rearrangement of machinery so as to eliminate unnecessary handling and improve work routing has been under way. Typical of this is the installation of mechanical flue-handling devices, the segregation of machine-tool manufacturing for store stock in locations where it will interfere least with shop operations, and the relocation of machine tools used in shop operation so that they will be where crane service is most adequate. Nor has the necessity for studying the location of raw-material-stock storage and changes necessary to minimize material handling been overlooked. In this same connection, it is worthy of note that certain machine operations have been transferred to the foundry location in order to reduce handling and conserve critical alloy turnings and borings for remelt with as little loss as possible.

IMPLEMENTING THE "MOVE THE WORK TO WORKMAN" POLICY

While shop operations and their relation to manpower conservation are being considered, one highly important factor in that connection must not be overlooked. In a rail system the size of the New York Central, the equipment-shopping demand for various parts of the System is a constantly varying factor. Peak demands in one location occur when ebb demands are occurring in another. The work load must, therefore, be distributed so that production will not lag at any point. Force increases of any consequence cannot be made, hence, the "move the work to the workman" policy has been adopted.

Every month, equipment which would normally be shopped at one location is moved to another, in order to level off a peak one place and build up the production at another. The necessity for this work equalization exists, not only between shop and shop, but between shop and engine terminal or car-repair yard. Such a procedure requires careful planning and foresight, but we have found that if it is properly carried out, no one other factor is of such great value in conserving and making more productive our available manpower.

COURSES OF TRAINING FOR SUPERVISORS

The training of personnel has been mentioned previously, in discussion of co-operation with national and state agencies to that end. Training not related to such agencies has been going on apace. Nearly 200 supervisors are enrolled in a series of foremanship conferences sponsored by management. All toolroom foremen have attended a course of study in tool tipping, grinding, and design. Welding foremen have had made available to them training courses designed to teach them the latest practices so important to the conservation of materials and manpower. These supervisors are now actively engaged in disseminating the information they obtained through these courses to those who work with and for them. Apprentice training, both in the shop and the classroom, is being carried on. Each of our major shops has an apprentice instructor. Apprentice classroom-instruction courses have been revised and modernized. Each apprentice has a sponsor in a supervisory position whose duty it is to aid the boy in every way possible. There are now on our rolls 808 apprentices, as compared with 667 as of January 1, 1941.

IMPROVED SYSTEM OF MAINTAINING PERSONNEL RECORDS

The final phase of manpower conservation, which to a large extent is new, and which is now proving to be of great value, is the instruction of a more adequate system of personnel records. In the past, personnel was something only the manager of personnel was interested in. Today, it is and should be the concern of every official. It was formerly a record of the past. Today it is a record of the present and a forecast of the future. We now know our mortality rate, our retirement rate, our rate of loss to the military services and to other industry, by localities, and for the entire Equipment Department. We also know our procurement rate and the number of vacancies by craft and class for the same jurisdictions. We further know exactly how many jobs we have, by I.C.C. classification and description, which can be handled by women employees. From a study of these rates and statistics, we believe we have a fair picture of our future needs and some idea of what we can do about it.

Having discussed in detail the actions already taken to conserve our manpower and make more effective that which is now available to us, it is felt that we should see what results have been accomplished thereby. This can perhaps be best done through statistics, and to that end the data given in Table 2 are submitted.

The first conclusion that must be drawn from these statistics and the factual situation is that thus far we have been able to keep our equipment up to a commendable standard of maintenance and operation, and also have been able to aid the Army and other railroads by giving general repairs to some twenty-eight of their locomotives, up to October, 1942. It has also enabled us to assist in promoting the war effort by forging parts for marine equipment and machining parts for tanks, combat vehicles, gun tracks, breech rings, bomb-handling equipment, and many parts for machines being built for war-production purposes. This in spite of the fact that as of October 1, 1942, we had already lost 2060 employees to military services and 6202 to other industries.

However, it does not follow that, because our present situation is as described, it will necessarily remain so; in fact, there is every indication in these statistics that an increased traffic demand, coupled with an ever-increasing drain of manpower

TABLE 2 PERSONNEL RECORD OF EQUIPMENT DEPARTMENT IN WAR PERIOD

	Mechanical employees on pay rolls		
Date	1-1-41	1-1-42	10-1-42
Mechanics	12170	13315	14002
Helpers	4085	4584	4874
Apprentices (regular and helper)	667	763	808
Total	16922	18662	19684

	Mechanics acquired	
Date	1-1-41 to 1-1-42	1-1-42 to 10-1-42
Mechanics hired new	1581	912
Helpers advanced to mechanics	746	750
Apprentices promoted on completion of course	105	42
Apprentices promoted in advance of completion of course	146	126
Total	2578	1830

Cause of loss:	Mechanics lost	
Mortality	119	86
Retirement	213	99
To military service	54	246
Resignations to accept work elsewhere	522	510
Other causes	525	202
Total	1433	1143
Increase, no.	1145	687
Increase, per cent	9.41	5.16

	Total number on pay rolls		
Date	1-1-41	1-1-42	10-1-42
All other employees	9195	10416	11018

	All others acquired	
Dates	1-1-41 to 1-1-42	1-1-42 to 10-1-42
Hired new	5103	6620
From other sources	677	523
Total	5780	7143

Cause of loss:	All others lost	
Mortality	88	93
Retirement	128	70
To military service	392	1368
Resigned to accept work elsewhere	1896	3274
Other causes	1460	1401
Total	3964	6206
Increase, no.	1816	937
Increase, per cent	13.02	5.95

to the military services and to other industries, will make necessary the adoption of other measures. This is emphasized by the fact that we now have over 1000 authorized positions unfilled.

PROBLEMS OF APPRENTICE SITUATION

In the apprentice situation, which is the key to skilled-personnel training, we are caught between two conflicting demands. On one hand we desire to and the Manpower Commission urges that we keep our apprentice ratio up to that permitted in our labor contracts (one apprentice to each five mechanics). This we have striven to do. But on the other hand, the Selective Service Act says we may ask for deferment only on such apprentices as have had 2 years' service. While the lower age limit of draftees was 21 years, the employment of apprentices at 18 years of age made it possible to augment our apprentice group by hiring young men of that age, and by the time they were eligible for induction into the armed services they were also eligible for deferment. Now that the age group 18 to 20 is eligible to draft, no such possibility exists. In some states even the hiring of men less than 18 years of age is illegal. Thus, unless some relief is obtained, our apprentice procurement will become hopelessly inadequate.

It is suggested by way of solving this problem that an understanding be reached as to what actually is the minimum apprentice ratio required and then that deferment for apprentices be allocated to the railroads in numbers which will produce that ratio. Only by such a means can replacements through apprenticeship be made, or the training of skilled-employee replacements in adequate numbers be accomplished. Such a decision should be made by representatives of the Association of American Railroads, Office of Defense Transportation, U. S. Employment Service, Administration of the Selective Service Act, and Labor, acting as a committee, whose decision would be final and binding. Deferments where the ratio was shown to be less than that figure set by this committee should, with possibly one exception, be mandatory on the part of the local draft boards and refusal of deferment where that ratio is known already to exist should likewise be mandatory.

In all fairness, an exception to this rule should be considered. Every organization has within its ranks certain employees who are not properly qualified (and who may never be, either through lack of diligence or natural aptitude) to perform successfully the work for which they are being trained. There is no exception to this among the apprentices in the railroad industry. It would be an injustice to the railroad, to the nation, and to such apprentices themselves, for their exemption to be requested. Consideration may well be given, therefore, by labor and management to the perfection of an understanding which will permit waiving of the deferment request where it is agreed that any apprentice has not the qualifications for nor the aptitude required to be developed successfully into an acceptable mechanic. This is no new idea. It is being followed in the deferment consideration for college students in the dental, medical, and engineering schools. A parallel situation in the training of mechanics for railroad work is apparent. Its pursuit in the railroad field would doubtless benefit all concerned by making more effective such manpower as is retained in the industry but at the same time avoid the possibility that some young men might, though not qualified, affiliate themselves as apprentices with the railroad, having only the thought in mind of guaranteeing their draft deferment. Uncertainty of his draft status has resulted in the voluntary enlistment of many much-needed apprentices. Certainty of the apprentices' status under this arrangement would correct this situation.

Furthermore, in this connection it should be recognized that special apprentices (graduate engineers) are also an absolute necessity on the part of any railroad. Heretofore, practically no consideration has been given to the deferment of such men. For example, the New York Central has definite need for at least twenty-five such men in training constantly. A year ago there were twenty-one on our rolls. Today there remain seven, and of these, one has been classified 1-A and will be inducted shortly. It is suggested that consideration be given to allocation of deferments for special apprentices by the same group which establishes the apprentice ratio for regular and helper apprentices.

MANPOWER MOVEMENT TO OTHER INDUSTRIES

From a glance at the statistics previously given in Table 2, it will be seen that the one greatest cause of loss of manpower during the past year has been resignations to take employment in other industries. This is particularly true in the group, "other than skilled labor," although even among "semiskilled labor," particularly helpers, its effect is serious. Some action should be taken to overcome this loss. The Canadian Government has already taken action, through their legislation, known as "Order in Council No. 7595," to cope with just such a situation.

While the results of special agreements between management and labor permitting the promotion of helpers to mechanics and the promotion of apprentices to mechanics after 2 years of service have been good, the statistics show that the possibilities under those agreements have now been practically exhausted. In many shops and localities, all available qualified helpers and 2-year apprentices have now been promoted. Furthermore, such action has alarmingly depleted the ranks of the helpers. It now, therefore, seems necessary to go a step further, reopen negotiations and provide a satisfactory plan of further relief. Any such agreement will, to be effective, have to make provision for emergency or temporary seniority. It is a self-evident fact that any skilled or semiskilled help as may be obtained through such agreements probably will not be needed by the railroad after the emergency is over. It is further apparent that the qualifications of such employees will not be such that they may be expected to be able to fill just any jobs to which normal seniority would entitle them. Consequently, it may be desirable to agree on the specific jobs which may be filled by such temporary or emergency employees for the duration of the war. If that is done, some provision will likewise have to be made for the vacating of those jobs by the more skilled regular employees now holding them and their arbitrary assignment to jobs which they can handle and the emergency employee cannot. To illustrate how this would have to work, let us take a specific example, as follows:

Regular employee *A* now holds a job on a single-purpose machine of a relatively simple type, say a bolt cutter. Employee *A* is satisfied with his job, and his work is satisfactory. His job, however, is one that it has been agreed can be handled by an emergency employee. A job on the bench, requiring considerable experience and of such a nature that it has not been listed as one which an emergency employee could handle, becomes open. Employee *A* is qualified for the bench job, but a newly hired emergency employee *Z*, is not. In this case *A*, by special agreement, would be arbitrarily assigned to the bench job and *Z* to the bolt cutter. Employee *Z*, of course, would acquire no permanent seniority but would hold seniority only on a special roster of emergency employees of his craft. When the emergency was over, *A* could, of course, retake his former bolt-cutter job if he so desired. Only through some such understanding can it be hoped to take full advantage of employment possibilities now available.

EMPLOYMENT OF WOMEN WORKERS

Here then women employees enter the picture. There are many jobs on a railroad, other than those formerly recognized as coming within a woman's capabilities, which they can do which are now being done by men who could well do a heavier or more skill-exacting job. A recent check was made of the possibilities in this connection and a tabulation of the positions outside of office work which it is felt could be handled by women employees is given in Table 3. This tabulation reflects that there is a total of at least 1850 positions where such a possibility exists, and that they include 130 different occupations. This indicates that through an arrangement of this kind a $6^{1}/_{4}$ per cent increase in force could be effected. No other known source of manpower, not essential for military purposes, could approximate the relief which could be obtained by this means. Hence, it is obligatory that we take advantage of it.

CONDITIONS OF FEMALE EMPLOYMENT

Some features in connection with the employment of women, on work available as described, will have to be considered. Considering first their seniority standing; here, the answer probably lies in setting them up as "temporary or emergency" employees and handling their seniority and job assignment in a manner already proposed for male employees coming under the same category. It is hoped that the details of that arrangement can be agreed upon between management and labor.

TABLE 3 CLASSES OF SHOPWORK FOR WHICH WOMEN MAY BE EMPLOYED

Classification	No. of different classes of work	Total no. of positions
Machinist (welder)	1	9
Machinist	30	52
Machinist helper	17	46
Boilermaker (welder)	1	10
Boilermaker helper	4	5
Blacksmith helper	2	7
Electrician	4	10
Electrician helper	1	1
Sheet-metal worker (welder)	3	8
Sheet-metal worker	4	16
Carman (welder and cutter)	2	25
Carman (painter)	3	30
Carman (upholsterer)	4	18
Carman (patternmaker)	1	1
Carman (others)	17	45
Carman helper	20	96
Crane operator	1	19
Oilers	1	3
Car cleaner	1	444
Truck operator	1	15
Janitor	1	11
Laborer (leader)	1	12
Laborer (common)	Various	559
Laborer (engine cleaner)	1	242
Laborer (sand men)	1	20
Laborer (supply men)	1	55
Laborer (water tester)	1	14
Laborer (grease-cup filler)	1	21
Laborer (turntable operator)	1	42
Laborer (material man)	1	13
Laborer (lubricator filler)	1	6
Laborer (engine watchman)	1	2
Total	131	1857

Some special training in supervision and work assignment of women employees will have to be given. This feature can readily be handled without outside assistance. Then the matter of adequate toilet and washroom facilities will have to be taken care of. A survey of our situation in this connection has already been made and it has been found that, except for a very few cases, no such facilities exist. In the procurement of the necessary materials for their construction, the assistance of the War Production Board will be needed. Doubtless both the O.D.T. and the Manpower Commission will be glad to lend a hand in the procurement of such a priority as will be needed in order to get these materials promptly.

STEPS TO ASSURE ADEQUATE MANPOWER PROCUREMENT

Summing up the actions considered necessary to insure the continuance of an adequate manpower procurement, the following pertinent suggestions have been made:

1 Allocation of deferments for regular, helper, and special apprentices to railroads on the basis of ratios set up by a joint committee of representatives from the A.A.R., Labor, O.D.T., U.S.E.S. and the Office of Selective Service Administration, under the limitations previously cited.

2 State legislation eliminating the inhibition against hiring men between the ages of 16 and 18, where such statutory restrictions exist.

3 Job freezing in critical industries, including the railroad industry. In England today, no man or woman can obtain or quit a job in an essential industry without the written permission of the Ministry of Labor. Likewise, no firm can employ or discharge a worker without the consent of that government department. The result is that no one can strike, walk out, or be locked out, and no one can lure the employee of another by an offer of higher wages. In Canada, similar action has been taken, and in our country, to some extent, it has occurred in the lumber and mining industries.

4 A management-labor agreement permitting the hiring of "temporary" or "emergency" employees, which likewise will settle the seniority question of such employees, and permit their assignment to jobs which they can handle; the reassignment of present incumbents requiring greater skill to jobs which they can handle, and the temporary or emergency employee cannot, it being understood that women employees shall fall in this category.

5 Prompt provision of trained supervision for women employees and likewise adequate facilities for their comfort and toilet needs.

6 A continued effort toward further efficiency in machinery, repair methods, labor-saving devices, work-load planning, safety, health, personnel training, personnel records, and co-operation between management, labor, and governmental agencies.

This six-point program, based on our past experience and our conception of future needs, is offered as our best suggestion for the maintenance of adequate manpower. That such a program, or one similar in many respects, is a national railroad need probably will not be denied. It is felt that if such a program is diligently carried out, not only in the Equipment Department of the New York Central, but as a national railroad policy, there will be no possibility of failure in this emergency. The manpower problem is not, by any means, the only one facing our transportation systems, yet adequate manpower, in the broader sense, will likewise furnish the answer to most of them.

Appendix

GOVERNMENT AND RAILROAD OFFICIALS DISCUSS RAILROAD MANPOWER NEEDS

In connection with the presentation of the paper by F. K. Mitchell, at the "Planned Conservation of Mechanical Manpower" session held by the Railroad Division of the Society on December 3, 1942, the presiding officer, D. S. Ellis, chief mechanical officer, Chesapeake & Ohio, and chairman of the Railroad Division, introduced prominent government and railroad officials who contributed their ideas on solving the mechanical department's manpower problems which are now approaching a critical stage.

Otto F. Beyer, Director, Division of Transport Personnel, Office of Defense Transportation, discussed labor utilization in a manpower-conservation program and described the benefits of the labor-management co-operative plan, as exemplified by experience on the Baltimore & Ohio, since 1924, and the Canadian National since 1925. Mr. Beyer's assistant, Dorothy Sells, who was scheduled to address the Railroad Division, delivered an address direct from London, England, by courtesy of the British Broadcasting Company, describing the important work now being done by over 100,000 women on British railways and outlining some of the conditions essential for the successful use of women in railway work.

Col. James L. Walsh, Chairman, War Production Committee, A.S.M.E., discussed the broad relations of logistics in war—the science of supply transportation—to the immediate necessities of that arm, as represented by the nation's railroads.

Paul V. McNutt, Chairman of the War Manpower Commission, said that no one now or in the future is likely to underestimate the vital necessity of the railroads in wartime transportation. He emphasized, however, that the deferment of railway employees subject to military service is not exemption, and railroads should make every effort to secure replacements with men who are older, with women, or minority groups, not previously employed. Mr. McNutt said the present and prospective demands for manpower are so great that both men and women must now be employed, part or full time, for what they can do and not be rejected on account of their respective limitations.

Dean A. A. Potter, Purdue University, stressed the importance of engineers who can design, build, and use civilian and war materials, including transportation equipment, and warned of a shortage of technical graduates three or four years from now unless more young men are encouraged to enter and remain in engineering schools. C. E. Brinley, president of the Baldwin Locomotive Works, described briefly the training of production personnel at the Baldwin plant. Brig. Gen. J. S. Hatcher, U.S.A., Chief of the Military Training Branch, Ordnance Department, showed how army ordnance forces, both officers and men, are given intensive training by the straight-line method now applied for the first time to educational processes. Andrew Stevenson, Director, Transportation Equipment Division, War Production Board, also made a brief address commenting on the equipment construction program recently authorized for the first half of 1943 and pointing out that the need for efficient production, in conjunction with certain limitations, as regards the size of steel plates available, for example, will necessitate confining both new locomotives and cars to a limited number of designs.

The important part played by the Canadian National in the war effort and the increasing use of women for mechanical work on this railroad were described briefly by E. R. Battley, chief of motive power, Canadian National. E. P. Gangewere, superintendent of motive power of the Reading Company, said that railroad maintenance work can in some instances be transferred from shops in industrial areas where there is a shortage of manpower to outlying points which are more fortunately situated in this respect.

Wood—the Most Important Raw Material of the Future

(Continued from page 182)

important for any one organization to cope with. War has indeed given a new significance and vision to the importance of research in wood. In the postwar period, wood will adjust itself to a new place and importance in this country.

THE RISE, FALL, AND RENAISSANCE OF LUMBER

This nation is the most important wood-producing and consuming country in the world. The use of lumber rose quickly with our expanding population to 1906, when 46,000,000,000 fbm were used. After several successive recessions in use with temporary rises in production in 1916 and 1926, and with the peak of prices in 1920, lumber use dropped gradually until in 1932, only 11,500,000,000 fbm were used. Prices of lumber even at the ceiling levels set by the O.P.A. are considerably below those of 1920. In 1942, the requirements for the war program were estimated to be 38,000,000,000 fbm. It is further estimated that only about 34,000,000,000 fbm can be produced. We formerly thought our sawmill capacity was far beyond the possibilities of use. Now it is deficient in meeting this enormous emergency demand.

With the forced substitution of wood for nearly a thousand distinct and separate uses and more coming along, wood is being rediscovered. There is indeed a rebirth of appreciation and understanding of the importance of wood.

The industries interested in wood have been literally forced into a position of paramount importance. The question naturally arises: Will these industries have the vision and the determination to hold and further develop these gains?

Molded Plastic-Bonded
VENEERS *and* WOOD *in* AIRCRAFT CONSTRUCTION

By ROBERT J. NEBESAR

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WOOD structures in aircraft design have been used since the beginning of this art. Wings of most airplanes, prior to the early 30's, were of wood construction, and some of these airplanes are still flying. A little later, wood was introduced also for fuselages and tail surfaces for the more modern stressed-skin constructions such as monocoque or semimonocoque designs. However, it was shortly replaced by metal.

The advantages of wood constructions are well known and need not be discussed at any great length.

The most important factor is the strength-weight ratio. Since the weight in aircraft construction is of the utmost importance, it must be considered in relation to the strength. Thus we use the formula for comparing the ratio of strength to weight as given in Table 1 for tensile and compression values.

The values contained in Table 1 were established on the basis of 3 sec duration of stress. Much higher stresses could be carried for shorter duration, as is the case in aircraft stressing where gust, pull-up, or landing loads are of the magnitude of the fraction of 1 sec duration. Furthermore, as aircraft structures are proved by static tests of considerably longer duration of loading, still greater margins of safety are obtained. The effect of duration of load on wood structures is shown in Fig. 1.

Even though seemingly slightly higher values could be obtained with special steels or some aluminum alloys for ultimate tensile strength to weight ratios, this slight advantage disappears by the necessity of having to make tension joints or connections. While in wood constructions, such joints are mostly made by gluing, without any decrease in strength, in metal joints made by riveting or bolting, severe penalties are introduced in strength because of decreased sectional areas and stress concentrations. Of course, both joints increase weight to a limited extent.

For strength-weight ratios at yield points, the advantage is chiefly on the side of wood, which is an important factor in so far as rigidity is concerned.

The block-compression strength-weight ratios are not especially favorable for wood. Since, however, the compressive strengths for most airplane structures are considered only as column or panel strengths where form factor is so important, the advantage again lies on the side of wood.

Since form factors depend mostly upon thicknesses which may be used for the same weight, and since higher thicknesses give greater rigidity, both of these facts allow higher stresses to be reached before wrinkling or collapsing. Therefore, panels of longer lengths can be used for wood structures, thus saving in rib or stringer spacing, with consequent savings in both weight and labor.

However, in stressed-skin structures, these considerations are partially outweighed by the fact that centroids of cross-sectional areas in wood structures, due to greater sizes or thicknesses, are closer to the neutral axis.

TABLE 1 TENSILE AND COMPRESSION VALUES OF VARIOUS MATERIALS

Material	Birch	Hickory	Maple	Yellow Poplar	Spruce	Low-carbon steel 1025	Chrome-Moly X4130	Nickel steel 2330	Aluminum 17ST	Aluminum 24ST
Unit weight, lb per cu in.	0.025	0.030	0.025	0.016	0.016	0.283	0.283	0.286	0.101	0.100
Ultimate tensile strength, psi	15500	19300	15500	9100	9400	55000	90000	120000	55000	62000
Elastic limit (tensile), psi	9500	10600	9500	6000	6200	25000	50000	60000	25000	32000
Ratio ultimate tensile strength/weight	608800	654000	608800	561700	580200	194300	318000	419600	544600	620000
Ratio elastic limit/weight	373000	359200	373000	370400	382700	88300	176700	209800	247500	320000
Compression strength (11 grain) wood	7300	8700	7500	5000	5000	55000	90000	120000	55000	62000
Ratio compression strength/weight	286700	294800	294600	308600	308600	194300	318000	419600	544600	620000

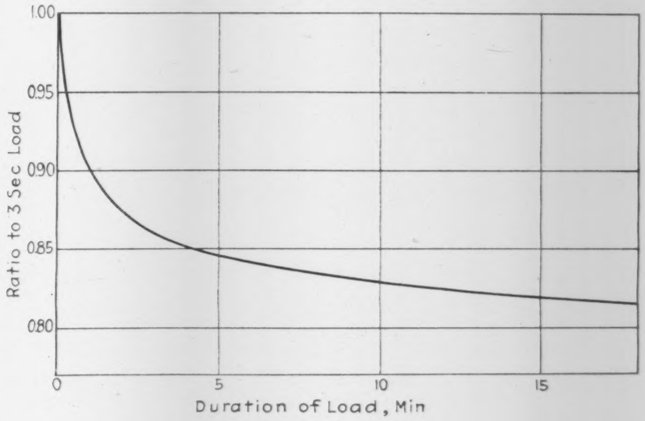

FIG. 1 EFFECT OF DURATION OF LOAD ON WOOD STRUCTURE

Contributed by the Aviation Division and presented at the Annual Meeting, New York, N. Y., Nov. 30–Dec. 4, 1942, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

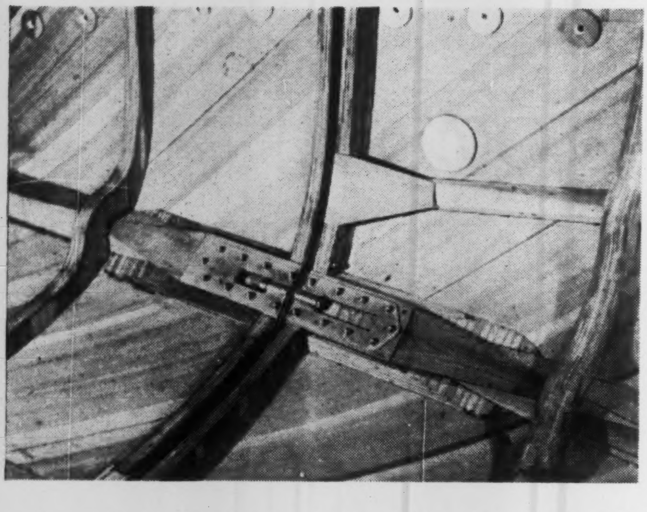

FIG. 2 CONSTRUCTION PROVIDING FOR DIRECT-LOAD DISTRIBUTION TO SKIN AND STRINGERS

It follows that in order to obtain the best advantages of design for wood construction, the design must be carefully planned and laid out.

Concentrated loads, such as those occurring at fittings of subassemblies, can easily be handled by laminated attachment blocks. Such construction, as shown in Fig. 2, provides for ample direct-load distribution to the skin and stringers without complicated fitting designs.

One of the most desirable features of wood construction is the admirably smooth skin, which stays smooth even under abnormal conditions, without wrinkling. This greatly increases the performance of airplanes, particularly the speed.

OVERCOMING OBJECTIONS TO USE OF WOOD IN AIRCRAFT CONSTRUCTION

The more serious objections to the use of wood in aircraft construction, which have been raised periodically since the beginning of this art, are as follows:

1 Difficulties were early experienced with vegetable and animal glues, particularly in relation to their durability, or stability, under varying atmospheric conditions. Dimensional and strength variations with time were also involved.

Such problems were solved with the development of waterproof and boilproof synthetic-resin glues. Two basic types are being used as follows:

Hot-Press Synthetic Resin. Such bonding agents are used at present in the molding process and in the manufacture of plywood. Different types have been developed, the principal ones being phenolics and urea formaldehydes. Both demand careful control in mixing the glue, spreading, and some control of humidity and temperature conditions.

As an example of such operations, the following are the requirements for the urea-formaldehyde thermosetting resin, known commercially as Plaskon 700-2:

This adhesive is composed of Plaskon 700-2A and 700-2B. The former is dissolved in water and stored for 24 hours at room temperature before mixing with the latter. The two constituents are then mixed in the ratio of 80 parts of 700-2A to 15 parts 700-2B, by weight. The amount of water for 80 parts of 700-2A may vary from 20 to 30 parts. The time limit for using any given mix of 700-2A solution is 4 days.

This hot-press glue may be spread within 4 hr after mixing at ordinary temperatures. The weight of the wet double glue line may vary from 20 to 40 lb per 1000 sq ft, depending upon the application intended. The assembly or lay-up time is much greater than allowed for spreading. Fig. 3 shows the estimated maximum permissible assembly time versus temperature. On the same curve the actual working range used by the author's company is indicated by the shaded area in the lower corner of the graph, which indicates the increased safety. It should be noted that the assembly time is defined as the time elapsed between spreading and the application of pressure and heat to form a bond.

However, it is to be understood that several variations of this glue were developed for different production items for operation at different temperatures.

The use of this glue, necessary pressure, and time of application, will be discussed later.

Cold-Press Synthetic Resin. These serve mainly in assembly work where molding cannot be used. Here again we will give an example of using the widely recognized urea-formaldehyde thermosetting glue, Plaskon 250.

This adhesive is obtained in the ready-mixed form which requires only the mixing of dry powdered glue with water in the ratio of 100 lb of glue to 65 lb of water. Plaskon 250 is mixed in quantities of 6 to 10 lb at a time and stored in a refrigerated compartment. The glue is then distributed in paper cups as needed to the various shops. Fresh glue is mixed every two and one-half hours throughout the working day and all unused glue is discarded at the end of each two and one-half hour period. Inert dyes of various colors are mixed with the cold glue as a means of distinguishing the status of the glue with respect to its permissible period of utilization. Actually the glue-handling procedure outlined is conservative, as such glue is reasonably safe to use as long as it is in condition to spread. By keeping each individual glue cup on ice, the pot life may be extended to about 12 hr.

Cold-press glue is allowed an assembly or lay-up time of only 15 min, that is, the pressure should be applied within 15 min after spreading. The weight of wet-glue line recommended for this type of glue varies from 35 to 40 lb per 1000 sq ft.

Both of these basic types of glues are stable for any extreme atmospheric conditions for many years.

2 Difficulties have been experienced in connection with the necessary interchangeability for mass production, especially for aerodynamically improved designs, involving complicated shapes and forms with complex composite double curvatures.

Considerable improvement has been made in this situation by a great advance in molding techniques.

Molding is essentially a process in which a bond is made between pieces of wood, wood veneer, or other materials by means

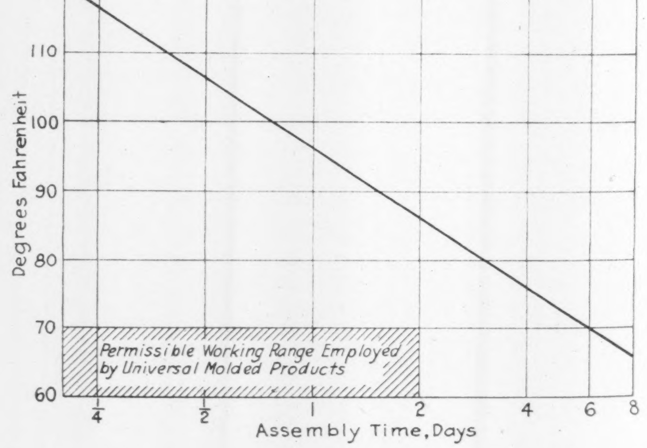

FIG. 3 MAXIMUM PERMISSIBLE ASSEMBLY TIME VERSUS TEMPERATURE: PLASKON 700-2

of applying fluid pressure and heat of the proper magnitudes through time intervals required to cure the particular bonding agent employed.

The molding process is utilized principally in the manufacture of flat plywood for general use and shaped plastic-bonded veneer structures of composite curvatures for specific uses. For most such shaped structures, other structural components such as frames, pads, and stringers are molded integrally with the plywood shell in one operation. This particular feature falls under the Vidal patents.

Detailed steps of molding process include:

(*a*) Spreading glue on the veneer and/or other pieces to be joined. This is accomplished by glue-spreading machines of different makes and different sheet-width capacities. Veneer which has been edge-glued to form sheets of larger sizes is thus limited as to sheet size by the glue-spreader width. Ordinarily, this restriction is of no significance in manufacturing shaped or curved shells for, in such cases, the veneer must be laid or wrapped in relatively narrow strips. It has been found that applying a double spread, that is, on both surfaces to be glued together, is superior to the single-spread method. For the components which cannot be accommodated by glue-spreading machines, the glue is spread by brush.

(*b*) Veneer-laying or wrapping is, as implied, simply forming the veneer to the mandrel or caul board on which the plywood component is to be shaped. If stringers, frames, pads, etc. are to be molded to the plywood shell, as is done under the Vidal patents, such parts are inserted in snug-fitting recesses in the mandrel prior to the veneer-wrapping operation, as shown in Fig. 4. Inserted parts are machined to come approximately just a little over being flush with the surface of the mandrel. Upon completion of the molding cycle, the inserted parts are bonded to the plywood shell to form an integral part of the structure. In wrapping veneer, the various strips are temporarily secured to the mandrel and to each other by staples. Hand-stapling machines are used for this operation. In view of the fact that the mandrels used in the molding process are made of wood, it is necessary to treat their surfaces to prevent bonding between the mandrel and the molded parts in locations where the adhesive can squeeze out. Acetate dope, or sometimes cellophane paper, have been found to be satisfactory for this purpose.

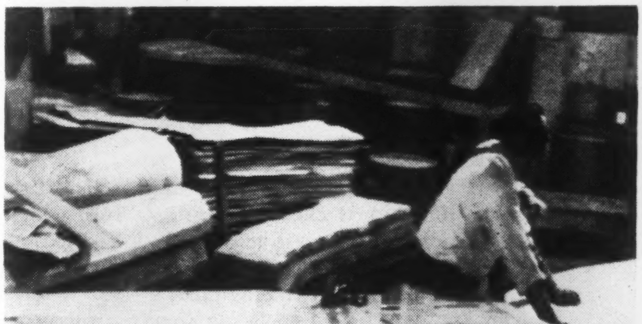

FIG. 4 VENEER-WRAPPING OPERATION AS PRACTICED UNDER THE VIDAL PATENTS

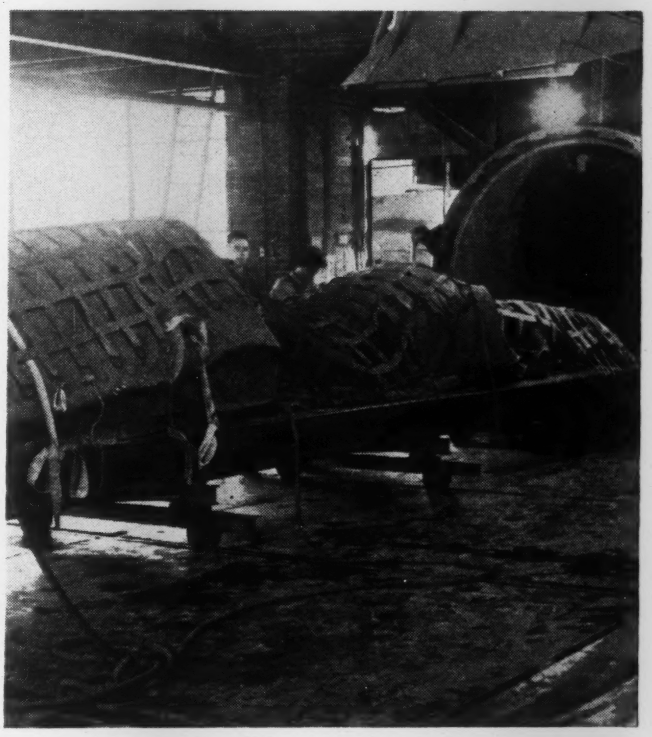

FIG. 5 AUTOCLAVE AND METHOD OF INSERTING UNITS TO BE MOLDED OR "COOKED"

While with the Vidal patents, mostly male-form mandrels are used, in the Duramold process the molding is done for skins only, using female mandrels, so that the outside of the skin will be as smooth as possible.

(*c*) The actual molding or cooking is done principally in autoclaves or pneumatic presses.

The autoclave used is fundamentally a large tank, Fig. 5, with a pressure-tight hinged end of heavy construction. After the veneer has been laid or wrapped on a mandrel, the mandrel is enclosed in a fluid-tight rubber bag and the whole is moved into the autoclave on a small car. The end door of the autoclave is then closed and secured. Hot water and compressed air are admitted to the autoclave to furnish the heat and pressure necessary to set the synthetic-resin bonding agent. The compressed air affords enough pressure to allow the temperature of the water to be raised beyond the normal boiling point without converting to steam. In the proper combinations the hot water and compressed air give the desired molding temperatures and pressures. The minimum molding conditions permitted are 50 psi pressure and/or 210 F temperature. It has been found desirable to apply full pressure to the autoclave within 4 min after the tank temperature reaches 120 F.

The time required to mold any given part is a function of the rate of heat penetration through the part. A rule of thumb employed for timing a "cook" in those instances where the thickness of the wood is appreciable is 1 hr per in. thickness of wood. This rule applies to the usual case where heat is conducted into the work from one side at a much greater rate than the other. Such conditions arise from the fact that on one side the work being molded is separated from the water in the

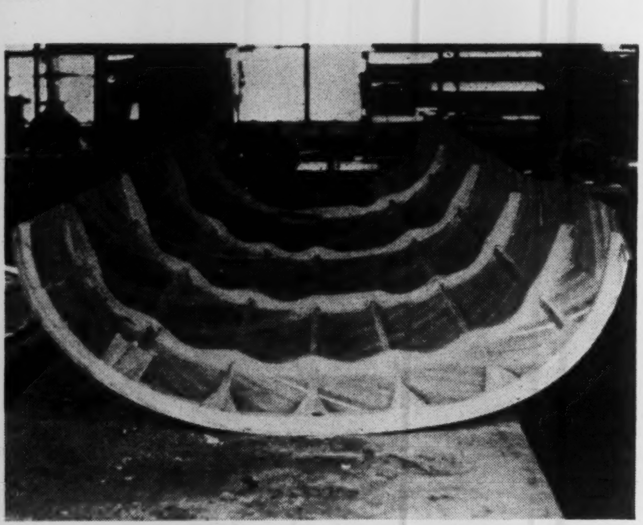

FIG. 6 SECTION OF A SEMIMONOCOQUE AIRPLANE FUSELAGE AFTER MOLDING

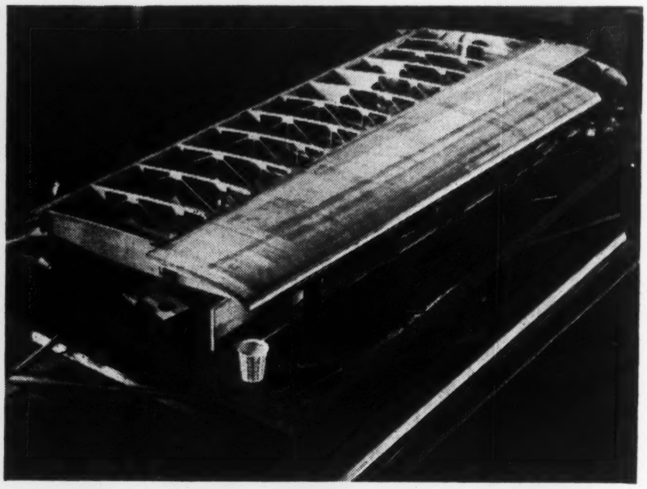

FIG. 8 WING-OUTER-PANEL SECTION WITH MOLDED NOSE SKIN

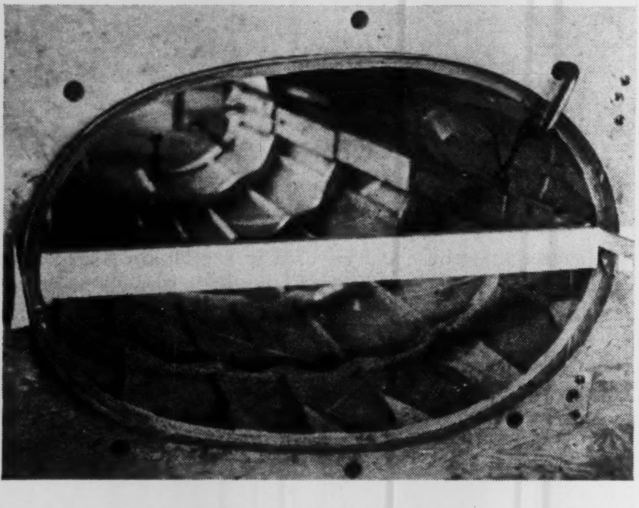

FIG. 7 ASSEMBLING HALVES OF SEMIMONOCOQUE FUSELAGE IN ENVELOPE-ASSEMBLY JIG

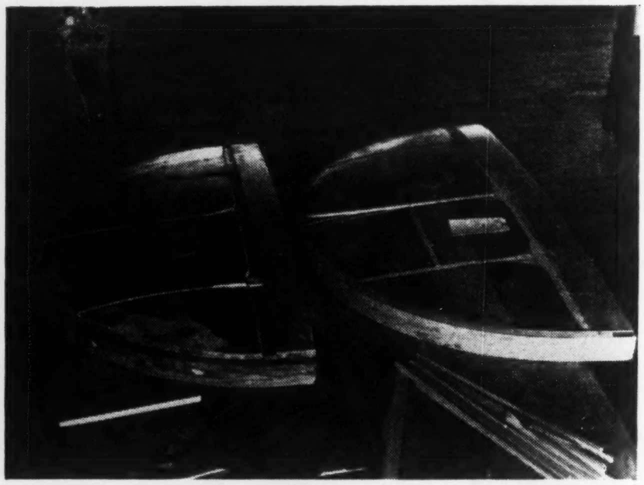

FIG. 9 HALF-WING-TIP MANDREL, ROUTED AND FITTED WITH STRINGERS AND ATTACHMENT PAD

autoclave only by the thickness of the rubber bag in which the work is enclosed, whereas heat transfer from the other side must take place through the bag and the mandrel or platen.

A successful steam-air cooking process has also been developed. In this process steam and air supplant the water as a source of heat and pressure. Compressed air is used, however, as a supplementary pressure medium to provide flexibility in the pressure-temperature combinations required.

Pneumatic presses of two types are used in addition to autoclaves for molding smaller parts. As in the autoclave, heat and pressure are furnished by steam and compressed air. For the production of small parts, pneumatic presses are very satisfactory because of the rapidity with which they can be loaded and unloaded.

At present the use of cold glue is essential to the molding processes. Practically all aircraft structural components of any size are molded in halves to facilitate removal from the mandrels. Cold-glue operations are employed to assemble such structures. It might also be said, with some reservation, that in all assembly work cold-glue processes are employed.

Since all assembly work is done with cold glue which itself requires perfect humidity and heat control within fairly close limits, it is here that interchangeability is achieved. Moisture content of wood is kept between allowable limits, thus preventing undesirable dimensional changes during fabrication. Of course, all dimensional wood must be properly kiln-dried.

To prevent changes after fabrication and when the structure is in service, different finishes are being used.

3 Problems are involved in providing aircraft structures of veneers and wood which will be durable under all weather and climatic conditions.

The most durable finish is achieved by covering all exterior surfaces by lightweight fabric, such as balloon cloth, which is doped on the surfaces over a special coat of sealer. Several other coats are applied over the fabric which gives the finish the required flexibility and elasticity, while the finishing coats and paint give the all-weatherproof durable finish.

Several types of other finish procedures have been developed, giving more or less adequate degrees of protection. For fabricless-type finishes, it is important to seal exposed end-grain surfaces with proper sealer compounds and to protect them with additional fabric tape. The interiors of the surfaces are finished usually by several coats of phenol-formaldehyde-derivative sealers.

4 Finally there is the problem of weight control.

As weight control is most necessary in aircraft construction, the variation in specific gravity of all types of wood species must be given proper consideration. Fortunately it can be stated that the strength properties of woods vary either in direct ratio to the specific gravity or even more rapidly, that is, with higher powers.

Existing strength data are, therefore, based upon the minimum values of specific gravity of species; and for weight calculations, somewhat higher values of specific gravity are used.

However, in the case of wood in general and for some species in particular, the range of specific gravity is very wide, which would affect the weight to a greater extent than is generally recognized.

This difficulty can of course be overcome by proper specifications and control. In some instances, it has been thought necessary to specify also the upper limits of specific gravity for some species.

EXAMPLES OF PRODUCTION

Some examples of molded plastic-bonded veneer and woods are presented.

Semimonocoque Fuselage. The aft section of the XBT-16 fuselage is a semimonocoque molded-plywood construction. In Fig. 6, the molded half of the fuselage is shown as it looks after the molding operation. The spruce longitudinal stringers are standard sections, produced by the author's company, and the frames are of laminated mahogany. Birch plywood is used in small quantities, principally for reinforcing material. The skin for the fuselage is two-ply poplar with the grain at 45 deg to the longitudinal axis of the fuselage. In the extreme end base of this fuselage, an additional ply is added to the skin for stiffness.

The two halves are assembled in the envelope-assembly jig shown in Fig. 7.

A cold-glue operation is employed to join the halves by an apron strip. With the installation of fittings and accessories, and after proper finish and painting, the fuselage is complete for final assembly.

Wing Outer Panels. The wing outer panels of the XBT-16 airplane are of two-spar skin-stressed construction. While the basic structural type is conventional, the execution of the detailed construction features sets the structure apart from the conventional category.

The wing outer-panel section with the front portion of the molded nose skin is shown in Fig. 8.

The outer-panel wing front spar, an I-section, is constructed of birch-plywood-web and laminated-hickory flange materials. Spruce flanges, molded to a Z-section, form the outer-panel rear spar.

Ribs are attached to the spar webs by standard plywood angles. Apron strips and molded skins themselves complete the tie-in structure for the rib-to-spar connections. The intermediate ribs are of the truss type, and the nose ribs are of the web type.

Wing Tips. Removable wing tips are constructed of birch-plywood skin with spruce stringers, laminated-spruce bow, and birch- and poplar-plywood reinforcements. The skins are molded in halves integral with the stringers, and half of the bow end with birch reinforcing pad through which the attachment-strip bolts pass. In Fig. 9, a half wing-tip mandrel is shown routed and fitted with stringers and attachment pad. Cold-glue operations are used to assemble the two wing-tip halves and to secure a few small gussets.

In Fig. 10, a complete wing tip is shown in the check jig.

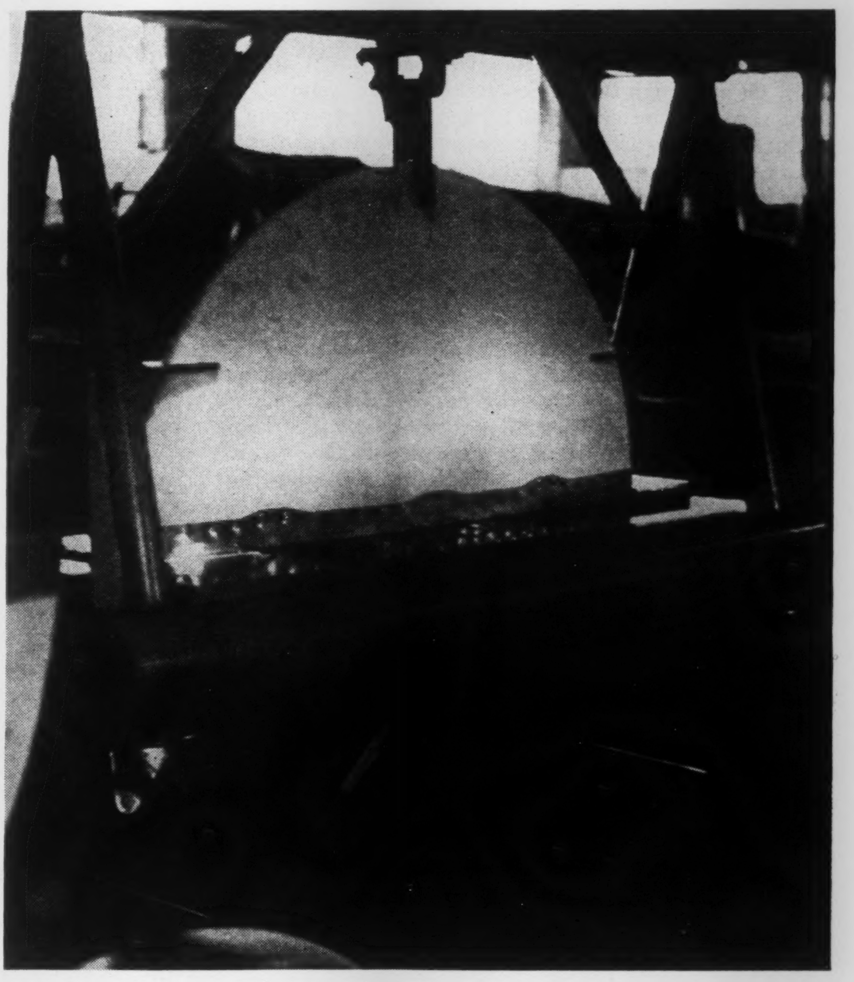

FIG. 10 COMPLETE WING TIP SHOWN IN CHECK JIG

ACKNOWLEDGMENTS

The author wishes to express his gratitude to the War Department for permission to present some of the information concerning the XBT-16 and also to the Universal Moulded Products Corporation.

Appreciation for collaboration is expressed to the management and to the Engineering Department staff of the Universal Moulded Products Corporation.

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The MAGINOT LINE *of* ENGINEERING EDUCATION

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THE DEAN'S PROBLEM

IN the administrative brackets of engineering education, life frequently takes on the aspects of that of a frog blinking into a hailstorm. The dean's office is continually being showered from the outside by plaints, sometimes very pointed, if not poignant, from alumni all over the world. Generally they infer that the college administration is not aware of the changing problems of engineers. They often suggest that new courses be given for the benefit of this, that, or the other industry. From the five-year alumnus comes the pleading for specific education at the training level. From the fifteen-year alumnus comes demands for a revamped curriculum to meet the demands of progressing industry at scientific levels. And at twenty-five years, the alumnus, careless of his profession in retrospect, may actually suggest that courses in art appreciation should certainly be squeezed in somewhere.

As though appreciation of art should be forced, and could be effectively taught, in the crowded curriculum of individual students keen to choose for themselves the paths of applied science. Or as though the curriculum should be revamped for every mushroom industry. Or as though low-level training in the tidbit courses available to the students of most engineering colleges would be worth the time of youth spent on them.

There is little wonder that the average ensconced dean stands conservatively confounded by the unending shower of missives, like the frog in the hailstorm sitting and blinking wordlessly on his lilypad, until a rising tide floats him out of his dilemma.

A NEED FOR ENGINEERING EDUCATION AT THE SCIENTIFIC LEVEL

In the field of industry there struggles and flourishes a group of technicians known variously as tool engineers, master mechanics, tool designers, tool superintendents, process men, and machine-tool specialists. They fall into two classes: (1) Those who make and sell machine tools to the manufacturing units; (2) those who must use the machine tools and adapt them to a specific and particular purpose.

All such individuals are properly tool engineers. But the second group actually are productive-tooling setup specialists, really should be called productive-tooling engineers. They are the ones counted on to know how to effect results with machine tools, machine-tool adaptations, and combinations.

They are the manufacturing strategists. They are the organizers of the batteries of machines for production. They design, make, arrange, and fit machines, tools, and equipment together so that the whole layout operates smoothly. They design combinations of long strings of machines to act as a single machine. They plan and supervise the layout of multiple strings in series and in parallel so that the whole plant may function as one grand productive tool. In connection with labor, their ideal of effectiveness is, "a maximum of results with a minimum of effort," which indeed is the functional ideal of industrial mankind.

They are, in addition, the watchdogs of competitive values; their business is to check the manufacture of an article which might reach the market at too high a cost. In this they may demand changes in design of the product, or they may call for investments in machinery and tools. In most large and vigorous organizations their function is considered an engineering duty; they are staff officers of the works manager or general plant superintendents, to which positions they frequently levitate. They are separated from product-design engineers to prevent overlapping authority. They are to such product engineers what the product-inspection division is to the production division. They check the sometimes weird product designs to make them adaptable to available production methods. They work hand in hand with the work-planning department to maintain balanced machine-tool loads. They are continually being confronted with, and in their own turn they present, manufacturing alternatives. No other engineering field demands so much in the understanding of applied mechanical principles and their multiform adaptations than the demands of productive-tooling engineering.

The education of such individuals has never been specialized in the larger universities. Such institutions have been unable to find an educational formula for such a product. Timidity in breaking into this large field on the part of the colleges leaves them at present rather in contempt of professional public opinion. When national emergencies arise to demand a response from engineering educational institutions, the offerings in this direction generally amount to little more than shop training courses, supposedly of the intensive variety. This sort of training is beside the point, however. The tooling engineers seem to work in a province beyond the ken of academicians, and the shop courses are either a demonstration of the latter's incomprehension of what is needed, or represent a tidbit offering to fill a *training* need in machine work at the artisan level, and have practically nothing to do with productive-tooling engineering in the professional sense.

Engineering colleges have frequently been asked to make some attempt to develop an effective curriculum for the education of tooling engineers. National engineering societies have made the requests. So have large manufacturing organizations. And so have many upper-class students and graduates of these colleges. Repeated requests, continued and urged as representing the most obvious social need for such education, have made no visible impression on the larger schools. From the response direct from the deans of those colleges contacted as well as from information elicited from professors and heads of departments under such deans, the writer has been given to understand that the old staid courses in mechanical, electrical, civil, sanitary, hydraulic, etc. engineering must be considered sound and sufficient with no great social need for other curricula.

This preoccupied if not actually reactionary attitude is generally taken to mean that those curricula, once established on a large basis for meeting a large need, are to be continued forever on that swollen basis. For instance, steam courses in the mechanical-engineering curriculum, once established in the pre-internal-combustion days as the mainstay of the mechanical-engineering sequence, are still a "must" subject in a university engineering college where not one mechanical-engineering graduate in five will ever put such material to use. Not that steam power plants are vanishing—only that more mechanical-engineering problems exist now and that the older courses of applied science cannot justifiably hold their places of bulk eminence when new techniques arise. But a brief survey made by the author among the staffs of a few of the larger colleges uncovered only a picture of inertia, if not complete indifference to large industrial needs. This was in the period beginning with 1940, the year when the general reader saw in the national picture-news publications a syndicated picture of a neatly bearded French soldier "standing" watch in a comfortable armchair, smoking his favorite briar, with his rifle across his knees, safely back on some escarpment at the rear of the Maginot Line. Those of you who saw that picture will get an idea of my feeling of the general academic position with regard to the problem of productive-tooling engineering education—inertia, preoccupation, and misconception: Misconception of the needs for such engineers; misconception of the future needs, but mainly misconception of the methods to meet the need; misconception as to how colleges on limited budgets can educate in this flashing field of rapid equipment change and development.

In the first place, at what level of instruction can courses in productive tooling be taught? The conception has been that machining work must be covered at the training level, but that there was neither time nor equipment to give students the training necessary for the mastery needed. From those administrative educators who do admit the need for new curricula in this field, this is an almost universal response to requests for a productive-tooling sequence. And the deans generally add that for the time put in, such courses hold too little of "engineering" values. It was admitted on both sides that small bits of technical practice were negative in effect if their purpose was to enable the student to gain even elementary control of such techniques as would enable him to comprehend significant differences in alternative machining methods. It was also agreed that mere description of the wide variety of productive machine tools and mechanical devices with their operation, as generally taught, or as such attempts have been made to teach it, were "picture-book" courses of even less value.

WHAT CAN THE ENGINEERING SCHOOLS DO?

What then are the alternatives?

We are here confining ourselves to the study of productive-tooling operations and alternative production methods. It will be beyond the ability of most schools to install production machinery of sufficient variety as rapidly as new machinery is invented and put on the market. It would be foolish to do so unless the school went into the manufacturing business, for nothing is deader than a production machine tool not producing. Besides it is unnecessary.

Quoting from Dean Barker of Columbia, speaking before the American Society of Tool Engineers:

"....here is the problem that the engineering educator is confronted with: In the first place, the machine-tool industry is a very rapidly progressing industry .... If we are not going to teach the boys in the engineering school obsolescent methods in machines, that means that we must keep our shops, if we have them, up to the minute. And any of you who are buying machine tools know what that would mean in the way of an investment problem. . . . ."

The Dean may have added also that the literature is rather barren of effective textbooks on the subject of productive-tooling principles and practices, a lack that might be remedied were the college people able to surmount the machine-tool problem and come to grips with the rationale of processing.

Also he might have added that procuring effective teachers of productive-tooling engineering at average college-staff pay likewise holds some elements of difficulty; for to be effective the teacher will have to be able to write his own text to cover fundamentals, and such men are rare and come high.

TWO EFFECTIVE METHODS OF APPROACH

Two clearly defined alternatives are available for the educational procedure of productive-tooling sequences. One, the well-known and gradually expanding co-operative type of engineering curriculum, insists on full coverage of machine-shop practices—always reinforced with apprenticeship on production floors of active manufacturing plants. In the classroom and shop laboratory, the theory—the logic of successful practice as developed by their forebears—is absorbed so that the student may gain an accurate understanding of what others have done, may do, or are doing; and it also provides verbal means for accurate thinking and for the conveying of mechanical information to others. In the factory a wide variety of jobs, correlated to classwork and made pointed through co-ordination reports by the individual, adds powerful authenticity.

Such is the present most successful four-year curriculum available today for educating productive-tooling engineers. But co-operative curricula cannot be made readily available to most students, especially those in universities not immediately accessible to industry. Besides that, co-operative educational facilities must be very efficiently regulated to be more than mere ways for poor boys to work themselves through college and into a job; and administration of such educational programs is a special development in itself.

The alternative method for gaining the same objective has a basis in the fact that any number of influential productive-tooling engineers, process men, and their higher-ups, have never run the machine tools whose operations they now plan and control. Many of them are college-trained; others are not. The college men, almost to a man, would say that they derived absolutely no feeling of benefit from their tidbit college shop courses. Others, graduates of liberal-arts colleges, never saw the inside of a college machine shop. But these are good men of especially active mentality, promoted to processing jobs because of the extraordinary need, and filling the jobs in spite of educational deficiency. All, I think, would agree that they could do a lot better had they been educated early for their work. They get their job done, they say, the hard way. But in conferences with many such men it is generally brought out that while they can "get things done," they don't brag about it, because they aren't sure there is anything to brag about, and they don't just know whether their methods are good or not—they've had experience—they wished they could express themselves better in words—why aren't there books?—they wouldn't be fumbling so much—they could tell their associates, subordinates, and superiors information that they wished to convey without so much groping and misunderstandings. . . .

The author knows, and the great organization with which he is associated knows what these men, experienced in the know-how of cut and try and lucky in the availability of records of previous practice maintained only by large companies, want. Those experienced tool men know that if they leave their jobs for similar jobs elsewhere they will make almost as many mistakes to begin with as any neophyte; that where the problem falls into the narrow path illuminated by the actual experience of their past, they can only to that extent proceed with confidence. For these men, professionally expert as they show themselves to be, need education in basic principles of mechanics as applied to the complexities of productive machining and processing. Something good for any time and place they can carry off the job with them. The means of filtering the floods of machine-tool advertising, so-called engineering bulletins, data sheets, commercial blanket promising, obscuring overemphasis of blurbs, and other practices, not to be able to separate the good from the bad, but to separate the more likely to be better from the more likely to be worse. Where can these fundamentals be learned? Where can they be given the logic of mechanics for their job? That is what they ask me. And that is what other tool engineers are asking these days of manufacturing turmoil. Turmoil? In many war-products plants the cost-plus-10-per-cent contract is like an oxygen tent. Initial methods are being established which in civil competition would suffocate the concern in waste. Aircraft parts have been made with a scrap production actually larger than good-piece production. Processors, brought in from other plants, haven't the fundamentals; they brought along with them only the cut and try of their past. They get their job done finally, but at the expense of tremendous and needless waste.

There is, of course, far more to productive-tooling engineering than cutting metal. But since the objection to establishing productive-tooling courses in colleges has rested on the belief that the great amount of shop apparently needed was insurmountable, the discussion here is limited to an abridgment of this single difficulty as well as the saving of much class-hour time.

A student undergoing a protracted training on a machine operation does not necessarily gain a comprehension as to the *relative* effectiveness of such an operation. Placed at another machine, details of operation consume much time, and the relation of one machining method as an alternative to the previous is not immediately seized. Given enough time and enough alternatives, significant differences in processes after a fashion dawn on the student. This is education at the training level, the student carrying away "something good" in the form of mechanic's training, even if the significant differences fail to register with him.

To get out of the training-practice level into the scientific level, the approach to a knowledge of significant differences in productive methods must be through training practice in the altogether different technique of time study. Time study, not being a productive pursuit, is an administrative tool, and as such provides data for the improvement of productive machining operations. It is a comparatively important and widely used industrial technique, the tools for which are simple enough to be fairly well mastered in about the same time it would take the student to master the details of a single production machine.

Work-standards and time-study men of industrial plants frequently are made over into skilled productive-tooling experts. They have learned processing evaluation through working out time studies of productive machining, productive assembling, and other operations. They have learned the facts of mechanical details, the speeds, the feeds, the actual and the possibrc, all through the practice of taking down data, itemizing, recording, analyzing, and comparing it in order to recommend improvement changes in the tooling. Time study is a technique for determining significant differences in industrial processes and well serves that purpose.

Most engineering colleges have time-study courses. Like the present shop courses, their purpose is for training in a simple technique for the sake of the technique itself. A lot of it is hypothetical in nature. Where instructors are far removed from actualities, the course is reported to be a bore. But where active investigators are available, using time study as a scientific tool by which an engineer is enabled to break down all the pertinent factors surrounding an operation, the course is something less than boresome.

Time study has to do with quantitative measurements and to that extent is on a sound scientific level. Time-study technique, studied as an end in itself, should never appeal to an engineering mind, any more than running a machine should be appealing. It must be, as it is considered in industrial engineering, a means to an end, subordinate to the main issue of dissecting the conditions surrounding a productive operation for purposes of edging toward that ideal maximum of results with minimum of effort, time, material. Considered in this light, it has "engineering values" of high order.

The technique of time study has been thoroughly presented by many authors. Among the more able texts are those by Holmes, Stegemerten, and Barnes. Terminology and practice have been developed for many years, established by such men as Taylor, Gilbreth, and others.

The college which can afford to support a typically small college machine shop can co-ordinate the activities of this shop to the needs of active time study. If put in the hands of a productive-tooling engineer, or one with equivalent vision and energy, it could at insignificant cost to the college be readily organized for the purpose of student study of machine-tool processes by directed time studies of those processes. Machines would not be operated just to show their capabilities to some fumbling student. They would be run on a repetitive operation by a proficient workman for demonstration of such an operation only. Pertinent data would be taken by the student. Skilled analysis of such data with the aid of the productive-tooling teacher would lead to changes in the tooling. Data on the second setup would be compared to the first. Differences, not otherwise determined by students, nor even by experienced technicians casually scanning the actual setups, thus become significant. Carefully chosen operations showing wide productive differences for certain changes and adjustments, which are easily and economically administered, would be necessary. But there is no limit to them; their effectiveness is dependent mainly on the ability of the supervisor of the course.

There is no need to labor the efficacy of time study as an open sesame to sound and effective courses in productive tooling for engineering colleges. Is there any question that a junior or senior, practicing this method of quantitatively observing an operation by another individual, highly skilled, would have a better analytical knowledge of that operation than if he spent the same time, multiplied by five, fumbling through the operation himself? I think not. A limited course of metal cutting might do little harm; but the range of the tidbit course is narrow; and for the broad coverage of machine-shop operations, particularly the use of properly related production setups, tools, and adaptations, it can be entirely eliminated.

One of America's first great educators, Thomas Jefferson, said of the academies of his day:

"They commit their pupils to the theater of the world with just taste enough of learning to be alienated from industrial pursuits and not enough to do service in the ranks of science."

Industry is a large part of our world as compared to that of the time of Jefferson, and the crime of such alienation ranks higher now in the scheme of things.

Space here does not permit presentation of an itemized course of study for the graduation of effectively educated productive-tooling engineers. To young men of brilliant mentality and high rationalizing ability, productive-tooling engineering offers the widest range for their efforts. The attraction of such a field lies in its activity, its rapidly shifting developments, and the necessity for keeping abreast of competitive practice. The problems, being mainly the realization of geometry in materials, give plenty of room for visual inventiveness. Tempering a natural aptitude for such inventiveness by a deliberate and thorough training, first of time-study technique, then by time study of a wide variety of machining operations, develops the

(*Continued on page 207*)

The Organization of TEXTILE RESEARCH *for* WAR

By F. S. BLANCHARD

PRESIDENT, TEXTILE RESEARCH INSTITUTE, INC., NEW YORK, N. Y.

THE chain of events let loose at Pearl Harbor, on December 7, 1941, had repercussions in textile research which will have a profound effect on the entire future of the industry—and on its use of fibers, both natural and synthetic. I shall not soon forget how I felt when, as a member of the Office of Production Management, transformed later into W.P.B., I went back to Washington after that fateful Sunday. As I was responsible for textile conservation, my first thoughts were about burlap and jute from India, manila from the Philippines, wool from Australia. Later I learned that I should have been thinking also about hogs' bristles from China (needed for noble combs used in worsted machinery and for paint brushes used by the Navy).

The immediate result was that burlap freezing meant cotton-loom limitation orders and investigation as to the further use of paper for containers. Wool conservation led to a great increase in the blending and use of other fibers, and this has led to a great deal of research on the warmth factors so important for many of the purposes for which wool is used. I know I learned for the first time of the significance of "compression resilience" in the maintenance of warmth, that is, the ability of the fabric or its nap to recreate the air pockets so necessary to warmth, after use and compression. Manila and sisal had to be replaced in part for cordage purposes by other fibers. Mildew-proofing, water repellence, flameproofing, and the combination of all of these in one fabric took on new importance.

ORGANIZATIONS CONTRIBUTING TO TEXTILE INDUSTRY RESEARCH

How is the textile industry organized to deal with those problems? I do not pretend to be able to give a complete answer to that question. All I shall attempt to do here is to outline the part with which I have some acquaintance; and this part will not include any discussion of the fine research work which many individual companies are doing, but rather those organizations representing group interests. These might be divided into the following categories:

1 Organizations representing textile associations, foundations, or membership groups.

2 Nonmilitary governmental organizations.

3 Research organizations representing the various branches of the Armed Services.

4 Educational organizations.

5 Research foundations, or institutes not primarily textile, or for some other industry.

In referring to the organizations noted hereafter, I shall confine myself largely to those with which I am most familiar and more qualified to speak, principally to the work of the Textile Research Institute and Textile Foundation.

In the first category, research agencies representing textile associations, foundations, and membership groups, are included:

(*a*) The National Cotton Council, in affiliation with the Cotton Research Foundation, has maintained a fellowship, under Dr. R. F. Nickerson, at the Mellon Institute, for several years. The Council, I understand, is also working closely with the Southern Regional Laboratory of the Department of Agriculture at New Orleans. I am not qualified to discuss the work they are doing, except to say that I recently saw some valuable preliminary results relating to one very important war job affecting cotton cordage on which Dr. Nickerson has been co-operating with the Textile Research Institute. The Council is devoting itself largely to promotion and research on cotton.

(*b*) The Cotton-Textile Institute has a director of research, John T. Wigington, with headquarters at Clemson College. Mr. Wigington works closely with the National Cotton Council and also keeps in touch with the cotton-research work of other agencies, furnishing members of the Institute with important summaries, analyses of research findings, and reports. The Institute has just announced the appointment of G. H. Dunlap, former instructor in Clemson College, as an associate of Mr. Wigington. Mr. Dunlap has been associated recently with the research work of the Southern Textile Association.

(*c*) The Southern Textile Association, through a group of its members, the Arkwrights, with the aid of a grant from the Textile Foundation, has been engaged in research work on the speed of cotton cards, thus aiding in breaking the carding bottleneck, which war requirements for coarser yarn have made a problem in many mills. Tests, run in a number of mills under the general supervision of G. H. Dunlap, indicate possibilities under proper conditions for increasing cylinder card speeds from the normal 165 to over 190 rpm, without loss of yarn strength, and even with a gain. More recent tests supervised by Mr. Dunlap show possibilities for substituting cotton squeeze-roll slasher blankets for woolen blankets. Thus war-production and wool-conservation purposes are being served.

(*d*) The National Association of Hosiery Manufacturers, through its associateship (now transferred to New York) at the National Bureau of Standards, has been doing important work on hosiery. This has become all the more vital by the freezing of silk and nylon for war purposes.

(*e*) The work of the Textile Research Institute and of the Textile Foundation will be described together, because under the co-operative arrangement made in the spring of 1941 both organizations, while maintaining their separate identities, are pooling their personnel and facilities in a united research program dealing with all types of textile fibers.

The facilities include those at the head office of the Institute at 10 East 40th Street, New York, and those of the Textile Foundation, located in space generously allotted by the National Bureau of Standards in Washington, where Dr. Milton Harris, director of research of both the Textile Research Institute and of the Textile Foundation, and his research associates have their headquarters.

ROLE OF TEXTILE RESEARCH INSTITUTE AND TEXTILE FOUNDATION

The following information, which describes the part played by the Textile Research Institute and Textile Foundation in

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Contributed by the Textile Division and presented at the Annual Meeting, New York, N. Y., Nov. 30–Dec. 4, 1942, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

organizing for war research work, is quoted from my annual report delivered on November 13, 1942, to members of the former organization:

Early in 1942 we recognized, as did the directors of the Textile Foundation, that from now on it was up to both of our organizations to concentrate our efforts on textile-research war problems.

Knowing of the wide variety of questions needing solution—and knowing also that many agencies were already at work on some of these problems, it seemed to us that our first job was to enlist the co-operation of the various branches of our industry, as well as the military agencies, in determining:

1 What were the most important problems.
2 What had already been accomplished on them.
3 How best to organize for further necessary research.

Accordingly, on April 7, 1942, we called a meeting of the heads of twenty-three leading textile associations, including associations (like our own) having important textile committees. We had a splendid response and decided to call the group thus brought together the "Textile Research War Council." We did not consider it wise or necessary to set up a new formal organization of this group, with officers, by-laws, etc., but rather felt that they could best work through the Textile Research Institute and its officers and facilities. We considered that the relationship of the Council to the Institute might be as follows:

The Council would be a valuable means through which important reports on military problems could be called to the attention of all branches of the industry. For example, our report on the mildew-proofing of military fabrics obtained wide distribution in this way. The new report on water repellency will also be distributed through members of the Council.

Members of the Council would be very helpful as points of contact for the discussion of problems involving their parts of the industry. For instance, at the suggestion of Mr. Appel of the Bureau of Standards, and at the request of the Hard Fiber consultants of W.P.B., I recently met with Mr. McDaniel, chairman of the Cordage Institute, and Mr. Quimby, secretary-treasurer of the Soft Fiber Institute, both members of the Council, to discuss the undertaking of a survey by ourselves to bring together the present status of research and the results to be expected from various fibers for cordage purposes, which would result perhaps in the organizing of further research on this subject. Both men were interested, as well as Dr. Murchison of the Cotton-Textile Institute, in the contribution which could be made by an organization like ours, the scope of whose work covered all types of fibers.

We hoped that the Institute might provide a means through which various branches of the industry could get assistance in the organization of research on their important problems.

The place of the Textile Research War Council may be clarified if the Council is considered, as we intended when we organized it, not as a functioning body, but as an advisory and co-operative group which functions through the Textile Research Institute. If you want to take a matter up with the Council as a whole or with any part of it, we—the Institute's officers and personnel—would be glad to assist in calling the appropriate people together, or in taking it up with them.

The organization of the Council played an important part in enlisting the interest and co-operation of the Quartermaster's Department, especially in the development of important research projects.

Here are a few of the jobs on which we have been working, and when I say "we" I refer to the Textile Research Institute and the Textile Foundation:

1 The conservation of wool: Dr. Harris is chairman of the Wool Conservation Committee of three set up by the Quartermaster. A panel on blankets has been organized, including qualified and representative members of the industry, to work on possibilities for conservation of wool and the substitution of other fibers in meeting military needs.

2 Substitution of cotton rope for manila and sisal: Dr. Harris is a member of a committee set up to deal with this subject, and we are now at work on it.

3 Possibilities for utilization of high-strength cotton yarns in order to obtain lighter-weight military equipment without loss in serviceability: We are aiding on this problem.

4 Committee on Aviation Clothing: We are working with this committee (of which Dr. Harris is a member) which is a subcommittee (under Dr. Newburgh) of the Committee on Aviation Medicine under Dr. DuBois. At high altitudes the temperature frequently goes to 40 or 50 degrees below zero, making the problem of maintaining life and efficiency at such altitudes one of our most serious challenges. We are now actively at work on this problem in co-operation with the committee. It involves questions of heat loss and its prevention which for obvious military reasons we cannot discuss here.

5 Accelerated aging of military fabrics: We are working on the problem of speeding up the tests which measure water and weather resistance and other qualities needed for military fabrics, such as duck, burlap, etc. While field tests may be the most reliable indication, it is important to get sufficiently dependable indicated results much more quickly through laboratory techniques.

6 Resistance of fabrics to ultraviolet light: We are co-operating on this matter.

7 Textile Research Planning Committee: Dr. Harris is a member of this committee of four set up by the Quartermaster, under the chairmanship of Maj. S. J. Kennedy, who is in charge of the textile section in the Quartermaster's Research and Development Branch.

8 Technical Subcommittee on Synthetic Textiles of the Office of the Quartermaster General: This committee was set up by the Synthetic Textiles Committee, which is under Dr. Schwarz of M.I.T. The Subcommittee is under the chairmanship of Dr. Harold DeWitt Smith of A. M. Tenney associates, our vice-president, and acts as a clearing house on rayon problems. We are co-operating with this committee, and the Office of Quartermaster has expressed a wish that its work be tied in closely with ours.

9 Special supplements to our magazine, "Textile Research," on military finishing requirements are being brought out.

10 Warp-sizing of spun rayons, already referred to, is being conducted under Dr. Harris' supervision partly at North Carolina State College Textile School and partly in our laboratories in Washington. It has been indicated that at least one third of loom stoppages are due to improper sizing, thus indicating the importance of this study to loom efficiency.

This concludes the quotation from the Textile Research Institute report.

NONMILITARY GOVERNMENT ORGANIZATIONS

The second classification of nonmilitary governmental organizations does not pretend to be complete, but it includes:

The Textile Section of the National Bureau of Standards, under the general direction of Warren E. Emley and the immediate supervision of W. D. Appel, as chief. Mr. Appel is also chairman of the Technical Research Committee of our Institute and works very closely with us in planning and undertaking research work. The Bureau has played a large and very important part in textile-research war work.

The Department of Agriculture, through its Agricultural

Marketing Division, maintains research and testing laboratories, including those at College Station, Texas, and at Clemson, S. C. The Bureau of Agricultural Chemistry and Engineering maintains regional laboratories, of which the Southern Regional Laboratory at New Orleans, with splendid laboratory and full-sized mill equipment, concentrates its work largely on cotton.

The War Production Board has recently organized an office of Production Research and Development under Dr. Harvey N. Davis, president of the Stevens Institute of Technology. The textile program of this office has not yet been developed so far as I know, and the methods of operation have not been sufficiently defined to make it clear what part they will play in textile research. It is intended, however, not to duplicate but to supplement the work of the Office of Scientific Research and Development, under Dr. Vannevar Bush, which has established the policy of confining its work largely to research dealing with weapons although it does include some textile work.

The National Research Council is also doing textile research, one instance being the work of the Subcommittee on Aviation Clothing, to which I have already referred.

QUARTERMASTER'S DEPARTMENT VITALLY INTERESTED IN TEXTILES

In the Quartermaster's Department, The Research and Development Branch, under Col. Doriot, has several sections which are interested in textile research, namely, the Textile Section under Maj. S. J. Kennedy, the Special Forces Section under Lieut. Col. Bestor Robinson, the Chemical Section under Maj. Clough, the Plastics Section, and possibly others. Research work is also done at the various depots, such as the work being done by Lieut. Col. Steadman in Philadelphia. The Quartermaster's Board under Col. Wainer also interests itself in textile research, particularly in field testing.

Other branches of the Armed Services are interested and important factors in textile research, including the Air Corps at Wright Field, the Engineers at Fort Belvoir, the Army Ordnance, and the Navy. Obviously most of their work cannot be discussed for reasons of military secrecy.

IMPORTANT WORK OF EDUCATIONAL INSTITUTIONS AND OTHER GROUPS

Educational institutions like the Massachusetts Institute of Technology, the various textile schools, and many others, are working on textile-research war problems.

Among the private organizations not primarily interested in textiles, the Mellon Institute is playing an important part in textile-research work, with a number of fellowships engaged on textile problems. The Institute of Paper Chemistry at Appleton, Wis., which I recently visited, and which is doing an outstanding research job for the paper industry, is also touching on certain textile problems. For instance, in connection with its work on the utilization of waste lumber products, it has interested itself in fibers from redwood trees for use in wool blends.

PREPARE NOW FOR FUTURE PEACETIME PROGRESS

We in the textile industry undoubtedly will face the severe competition of other industries after the war, including that of the paper industry, to a degree greater than many of us may now realize. If we are to hold and develop our position in American industry, it is up to us to unite in the support of textile research as the paper industry has backed up its splendid Institute of Paper Chemistry, and as the gas industry is backing its recently organized Institute of Gas Technology.

There is a great deal to be done and, provided there continues to be the close friendly co-operation which I know from personal experience exists between many of these agencies, we need not fear that there will be too much duplication. Let us all hope that, born of the war, there will come a united effort on the part of all branches of our industry to raise textile research from the relatively small part it has so far played in the life of our industry to the high plane where it belongs.

War Rubber Problem of the U. S.

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however, depend on the expenditure of critical materials. Therefore, the amount of petroleum, gases, butane, butylene, etc., that can be made available is limited.

The petroleum gases are available from two sources, the natural-gas fields and as refineries' products. Lean gas from the fields is returned to maintain field pressures. The greater part of petroleum gases must be diverted to war use for manufacture of high-octane gasoline and synthetic rubber.

Agricultural products are a source of alcohol which like the petroleum gases can be converted into butadiene and thence into Buna types of rubber.

SYNTHETIC RUBBER IN THE POSTWAR ECONOMY

The war necessitates a tremendous increase in the capacity of a number of plants producing materials like metals, aviation gasoline, rubber, and other war essentials. As far as can be foreseen at present, most of these industries will be overdeveloped for the postwar economy, and it will probably take a number of years before the peacetime demand has grown sufficiently to utilize the increased plant capacity. In many instances, the plants will be obsolete before the supply catches up with the demand. A number of plants will probably have to be shut down after the war, and some which are at present the most important in the war effort will be in a difficult position after the war.

The synthetic-rubber industry from present indications is an exception in this respect. It is not conceivable that a repetition of the present rubber situation will be permitted. Therefore it can be reasonably expected that the importation of natural rubber from other continents will not be relied on exclusively. The synthetic-rubber industry in all probability will supply the peacetime demands of the country. This will be particularly true during the years immediately following the war when the requirements of the automobile and other industries will be great and the amount of natural rubber available from rubber plantations will be practically nonexistent.

Maginot Line of Engineering Education

(Continued from page 204)

very best manufacturing strategists and tacticians—the veritable staff and field officers of the industrial front.

Thus we see two clear alternatives for the education of productive-tooling engineers. One goes all out for shop practice and production floor experience through co-operative training arrangements between the classroom and the manufacturing plant upon which to build the analytical courses of the senior year. The other on a higher, but not necessarily more vague, educational level, gains the same analytical mastery through basing such analysis on the student's personally taken time studies and reports of actual practice as performed by experts. The first has possibilities of complete success only in favored locations. The second, and I have met with no denial from engineers in this, has equal possibilities for university colleges; but only where the staff may not be typified by a soldier stolidly seated in a tipped-back chair on a well-protected escarpment of the Maginot Line.

PROGRESS IN COLLECTIVE BARGAINING[1]

By CHARLES A. MYERS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

IT IS unlikely that the upsurge of unionism which has taken place since 1933 will be checked by the war. On the contrary, unions will probably emerge with greater membership than ever before. Collective bargaining as a practice in industry is here to stay. A comprehensive book analyzing "how collective bargaining works" is, therefore, particularly useful at this time and for the future.[2] It is a book which *Business Week* has described as: "By far the most complete and objective treatment of this subject ever undertaken. . . . Out of it all comes a rounded picture of collective bargaining in America—its history, its hazards, its threats, and its promises."

The book is the result of factual surveys of labor-management relations in sixteen major industries. These were made under the direction of Dr. H. A. Millis, formerly of the University of Chicago and now chairman of the National Labor Relations Board. Dr. Millis has had a wide experience as an arbitrator in a number of industries, and the research staff which he assembled here included many who were already intimately acquainted with the industries selected for study. The findings can therefore be accepted as thoroughgoing and authoritative.

It is impossible in a brief review to summarize the wealth of information and observations on collective bargaining that this book contains. There are detailed discussions of the growth and maturity of unionism in such industries as men's clothing, daily newspapers, book and job printing, hosiery, railroads, bituminous coal, anthracite coal, and building construction. Frequently, the later experience in these industries is in sharp contrast with the beginnings of unionism in such mass-production industries as steel, automobiles, glass, rubber, and electrical products. Finally, there is an analysis of collective bargaining in the "service industries," such as cleaning and dyeing, motion-picture operation, and professional music.

MANAGEMENT-LABOR ATTITUDES

Little attempt is made to point out similarities in the experience in different industries, but the reader is struck with the fact that one important condition for successful collective bargaining is the conciliatory attitude of management and union leaders. This is well stated in the discussion of collective bargaining at the East Springfield plant of Westinghouse. Here the success was explained in large part by "realization by leaders (of the local union) of the need for tempering aggression with patience and compromise; and management's recognition that the union was a going concern and its consequent decision not merely to 'play ball' with it but to get the greatest possible value from its existence."

As every headline reader knows, sit-down strikes, lockouts, and violence on both sides marked the first turbulent years of union-management relations in the automobile industry. But it is perhaps less widely known today that: "The rapid evolution of unionism has been accompanied by equally striking change in the attitudes and tactics of both management and union. Auto managers, long known for their uncompromising resistance to labor organization, are now for the most part sincerely attempting to develop working relationships with the union, while the union policy, which was sharply belligerent three years ago, is now marked by a more definite acceptance of responsibility."

UNIONISM IN THE RUBBER INDUSTRY

Unions were first organized in the rubber industry about the same time as in the automobile companies, but less progress has been made toward stable relations. The local unions in Akron consider that their primary job is "to enable labor to adjust itself to steadily shrinking job opportunities with a minimum of human suffering, and on an equitable basis, free from discrimination or favoritism." Their approach and outlook has been essentially negative. On the other hand, "to management, the union represents a definite limitation of its authority." Except for one firm, "the conclusion seems inevitable that most employers in the rubber industry, large or small, have little liking for the principle of unionism and would welcome an opportunity to get rid of it . . . . Management's approach to collective bargaining has generally been the negative one of yielding as little as possible in return for peace in the plant and uninterrupted direction of production."

The study concludes that "collective bargaining is still in its initial stage in the rubber industry and that the future is not yet clear . . . . In plants where collective bargaining has gained a foothold, management and union now face a fundamental problem of learning to live together, whether they like each other or not . . . . Considerable adjustment is necessary on both sides . . . . The indispensable first step in satisfactory collective bargaining is unqualified recognition of unionism by management and then a willingness on both sides to 'play ball' under fair rules."

THE DAILY-NEWSPAPER INDUSTRY

A good example of an industry in which management and labor appear to be "living together" amicably is the daily-newspaper industry. Efforts to organize newspaper editorial employees have commanded public attention in recent years, but collective bargaining has a much longer, though less dramatic, history in the mechanical departments of daily newspapers. Typesetters, stereotypers, and photoengravers formed some of the earliest labor unions in this country, and as national organizations they have been dealing for years with the newspaper publishers and their associations. "Few industries," according to this study, "have had as interesting and meaningful experience with collective bargaining as newspaper publishing." The unions in co-operation with the publishers "have developed bargaining relationships that in many respects are remarkable."

The keystone of these relationships is the provision for local and national arbitration of virtually all disputes that arise. As an employer member of the "special standing committee" of the American Newspaper Publishers' Association said: "The newspaper industry has one of the most efficient and mutually satisfactory nation-wide arbitration plans in the country. Its record for harmonious relations ranks among the best in the country, if actually it is not the best." According to this study, strikes and lockouts have been prohibited and, further than that, the arbitration system has fostered "conciliatory attitudes on the part of both employers and employees, and . . . a sense of responsibility for fulfilling contractual obligations."

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[1] One of a series of reviews of current economic literature affecting engineering, prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of The American Society of Mechanical Engineers. Opinions expressed are those of the reviewer.

[2] "How Collective Bargaining Works, A Survey of Experience in Leading American Industries," under the research direction of Harry A. Millis, The Twentieth Century Fund, New York, N. Y., 1942, 965 pp., $4.

There are economic reasons why collective bargaining has been so successful in the newspaper industry, but behind these is "the able and farsighted leadership long enjoyed by both sides." When the American Newspaper Publishers' Association, for example, formed its committee to deal with the unions in 1900 it stated that the purpose was "not . . . to provoke controversies or to antagonize labor, but on the contrary to promote a better understanding between union members and their employers." This was in sharp contrast to employers' associations in some other industries.

Collective bargaining has not, of course, been all "milk and honey" even in the newspaper field. Real differences have arisen between the unions and the publishers over the regulation of working conditions. Straight seniority is required by the unions in layoffs and rehiring, and the publishers with some truth hold that "seniority impairs their right to employ and to retain the most efficient workers in preference to those of average competency." The seniority rule, however, was drawn up when foremen abused the unrestricted right to select the workers who were to be laid off as the force was reduced.

BOOK AND JOB PRINTING

Another industry in which collective bargaining has had a long experience is the book and job-printing business. This is more competitive than the newspaper industry, and "employers, who on some points are highly critical of the unions, look to them for help in the solution of one of their most serious problems—cutthroat competition." Wages are about 30 per cent of sales, and materials costs are uniform, so stabilization of labor costs and working conditions has a real influence in reducing this type of competition.

As in the daily-newspaper field, some of the union rules on seniority and manning of equipment are cost-raising, but against these are influences which may reduce costs. The pressmen's union, for example, gives advanced training on presswork and makes the results of its technical research available to employers, many of whom are small and could not afford the cost of extensive research themselves. In some of these smaller plants, management efficiency is apparently relatively low, and "the necessity of paying higher wages on a union basis forces management out of its comfortable rut, induces careful selection of the more efficient workers, better organization of production, more prompt layoff when work is not available, more frequent purchase of new equipment, and a general increase in the efficiency of operations."

ELECTRICAL PRODUCTS AND RADIO

Collective bargaining is a relatively new development in the electrical products and radio industry. In such an industry, where outstanding and progressive firms, such as General Electric, Westinghouse, Philco, and R.C.A., are dominant, what does unionism have to contribute? In each of these, a C.I.O. union won bargaining rights by elections, though sometimes after strikes. One thing the unions helped to do here was to set up a more satisfactory procedure for handling grievances. In connection with this, some of the companies found that they had to devote more attention to labor relations, and frequently an industrial-relations director was appointed to co-ordinate the decentralized authority that foremen previously had on labor matters.

The union also secured changes in the layoff and rehiring policies, giving more emphasis to seniority. However, "seniority" was never the sole consideration in slack times, because work in a department was equally divided before transfers and layoffs were made. The new layoff and rehiring rules did limit management's ability to retain or select the most efficient workers, but they also eliminated the favoritism which had been practiced by some foremen in the past.

In at least one plant (Westinghouse in East Springfield, Mass.) union-management relations have progressed to the point of real co-operation on production problems. A joint campaign to reduce scrap loss was carried out successfully, after all efforts by the company alone had fallen short of the mark. The actual economic gain of this program is difficult to assess, but "even if its economic value is slight, the scrap campaign would be worth while for its influence on labor relations. Through the joint departmental and interdepartmental committee meetings, it had given employees and the supervisory officials clearer appreciation of each other's problems and has destroyed many bases of misunderstanding and antagonism." Many of the joint labor-management committees set up under the War Production Drive in hundreds of war plants are proving the truth of this statement today.

UNIONISM AND THE MUSICIANS

In sharp contrast to collective bargaining in printing and publishing or in the mass-production industries is the character of unionism in a "service industry" such as professional music. The American Federation of Musicians, and particularly its president, has received considerable attention from newspaper and magazine writers. Many of the facts are damaging and readers are sometimes led to the conclusion that unions generally behave in the same manner.

The unemotional account of the Chicago musicians' union in this book does not whitewash the tactics of the union, but it tries to explain them against a background of the nature of the industry and labor market. Professional musicians are employed under a variety of circumstances. There are numerous short engagements; musicians circulate from job to job in a city; and employers range from fourth-rate cabaret to swank night spots, and from vaudeville to symphony orchestras and radio networks. In the absence of the control exercised by the union, competition between musicians for jobs could in many cases lead to very low wages and working conditions. Instead, through its undeniable strength the union literally charges "what the traffic will bear" in the different "engagements" in which musicians are employed. There is little question, however, that the union has exercised its power in the form of a monopoly control of musicians' services.

Like the practices of the Chicago cleaning-and-dyeing, and motion-picture-projection industries discussed in this book, the activities of the musicians' union "appear in the nature of adjustments to the specific economic and industrial forces surrounding them." This leads to the conclusion that "any rational recommendations concerning a public program for regulation of collective bargaining, therefore, ought to begin with an appreciation of trade-union action as a product of the market and industry in which it is found."

This same observation is worthy of the thoughtful consideration of any management official facing union negotiations for the first time. Generally, a labor union develops out of the environment of the industry and the locality, and no two are exactly alike. "Getting along" with unions involves understanding them, and this book makes a major contribution to that understanding.

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Women in Engineering

Comment by K. B. McEachron, Jr.,[1] and J. E. Ryan[2]

The writers have been greatly interested in the experience of the authors in recruiting women for pre-employment training in engineering work, as outlined in their recent paper.[3] It has been pointed out in other discussions that the lack of response to such training programs may be due in part to the reluctance of trainees to forego attractive earnings during the training period. The General Electric Company has not been confronted with this difficulty since the college women being offered training courses have been placed in semiskilled testing work which they can do at once. Thus, while they are doing productive work, they are receiving instruction in engineering subjects which will fit them for eventual work in engineering departments.

These women have a wide variety of backgrounds, ranging from graduates in fine arts to physics and mathematics majors. None of them has an engineering degree. Moreover, even those with the more scientific preparation have had little contact with the construction of electrical and mechanical devices. As a result, any effective course of training must contain, in addition to theory, much information on practical applications. In spite of the diversity of background, each woman in training realizes that she has a great deal to learn, and it has not been at all difficult to maintain active interest in the courses. This interest, we believe, is the most important single factor affecting the progress of women in engineering.

Two different methods of training are being tried within the General Electric Company. The first consists of classroom and laboratory work in mechanics and electricity, starting with the most fundamental concepts. Naturally, some are able to advance more rapidly than others, and for most efficient instruction it has been necessary to divide the group. With this basic knowledge the trainees are better able to understand the explanations of their factory supervisors in connection with the testing work. The testing department rotates these young women to jobs in different sections every 3 months to give them varied experience.

The second method of training is more nearly an engineering-apprentice program. Each young woman is assigned to an engineer, assisting him as her training permits. The information that she obtains from the engineer on the job is augmented by classroom instruction. In contrast to the method first described, which emphasizes fundamental concepts from the start, the first weeks are spent in a quick qualitative survey of power generation, distribution, and utilization. Although most of the students are unable to grasp all of the ideas presented, much of the vocabulary remains with them and quickens their interest. After this, the engineering principles underlying the work of their particular department are studied quantitatively. Consequently, the training is more specialized than the first method, but it contributes more directly to the usefulness of the trainees in their immediate jobs.

Comment by G. B. Carson[4]

It should be pointed out that efforts to interest the higher classes of women (college graduates and those with advanced degrees) in jobs in industry must be accompanied by an enlightened placement policy after the training period.

At Case School of Applied Science, for example, we have been training women on a full-time basis for about 9 months. These women are paid $120 per month during their training period.

We solicited and obtained excellent cooperation from the various women's clubs in the recruitment of trainees, until the first group, in which there were a few of the better students, had been on their assigned jobs for a few weeks. An illustration will clarify the reason for the sudden cessation of interest on the part of the club women in the program.

Miss "A" finished the course badly but was finally passed. She was attractive in appearance and was placed in an interesting position. Miss "B," who had far better aptitude, training, and interest, and who did an excellent job in all phases of the course, was physically less attractive; she was placed in an uninteresting routine task and left there. After a few weeks the word was passed back that if one wanted to make any real contribution to the war effort, technical work was not the field to try.

Unless our training programs are followed by enlightened and well-organized placement programs, the more capable women will not be attracted. Feminine pulchritude and politics must not prevail as criteria for placement, if our technical training is to attract any great number of women having suitable qualifications.

Euler's Number

To the Editor:

The writer would like to suggest the name "Euler's number" for the dimensionless group of quantities $\rho v^2/p$, or density times velocity squared divided by pressure.

Within recent years the applications of dimensional analysis to hydraulics have been described in so many articles and textbooks that this subject is no longer a mystery to practical engineers. One of the familiar theorems based on such analysis is that the generalized equation for flow of a liquid can be expressed in the form

$$f\left(\frac{vl\rho}{\mu}, \frac{v^2}{gl}, \frac{\rho l v^2}{\sigma}, \frac{\rho v^2}{e}, \frac{\rho v^2}{p}, r_1, r_2, r_3, \text{etc.}\right) = 0$$

where ρ, μ, σ, and e represent the density, viscosity, surface tension, and elasticity of the liquid, g the acceleration of gravity, l any linear dimension of the system, v the velocity of any one fluid particle, p the pressure on any one surface element, and r_1, r_2, etc., dimensionless ratios defining the geometrical shape of the system. The first four of the five dimensionless groups of symbols in this equation are known respectively as "Reynolds' number," "Froude's number," "Weber's number," and "Cauchy's number." The lack of a recognized name for the fifth group, $\rho v^2/p$, leaves an awkward gap in the nomenclature of this field of hydraulics. This gap might well be filled by the term "Euler's number."

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[1] General Electric Company, Schenectady, N. Y.

[2] Development Engineer, General Electric Company, Schenectady, N. Y. Jun. A.S.M.E.

[3] "What Can Be Done to Train Women for Jobs in Engineering," by R. H. Baker and Mary L. Reimold, Mechanical Engineering, December, 1942, pp. 853–855.

[4] Associate Professor, Industrial Engineering, Case School of Applied Science, Cleveland, Ohio, and Research Engineer, Cleveland Automatic Machine Company.

The dimensionless combination $\rho v^2/p$ expresses a relation between the inertia of an element of the liquid and the pressure acting on some element of the liquid's surface. It thus involves one property of the fluid (density) and one property of its environment (pressure on some area element of the solid or gaseous boundary). Certain hydraulicians tend to follow Hunter Rouse in considering that this combination is so different in nature from the four others that it should not be named after a person but should simply be called "the flow parameter." In support of this they argue that each of the four named combinations involves merely properties of the fluid itself and not of its environment. Thus:

Reynold's number involves density and viscosity
Froude's number involves density and specific weight
Weber's number involves density and surface tension
Cauchy's number involves density and elasticity.

However, it would appear that this argument is not really tenable with respect to Froude's number, since density and specific weight are not independent properties of the fluid. More properly, Froude's number involves density and gravitational field strength, thus involving one property of the fluid and one property of its environment. Thus the dimensionless number $\rho v^2/p$ is closely analogous to Froude's number in fundamental nature and is equally deserving of being named after a person.

Probably the reason why this dimensionless group of symbols has failed to attract sufficient interest to cause it to receive a special name is its lack of practical utility in the vast majority of hydraulic problems, where atmospheric pressure acts alike on all free surfaces and thus produces no effect on the velocity. However, there is one hydraulic phenomenon in whose investigation this group is of paramount importance. This is cavitation, where water-vapor pressure acts on the free surfaces lining the cavitation pockets and atmospheric pressure acts on other free surfaces, the flow being profoundly influenced by the difference of these boundary pressures. In studies of cavitation by means of tests on natural-scale models, an inconvenient circumlocution in describing the fundamental requirements for similitude can be avoided by the use of the simple statement that the "Euler's numbers" of the model and prototype must be equal.

No modern hydraulician has utilized this dimensionless combination on investigations sufficiently important in comparison with those of Froude or Reynolds to justify giving it his name. In Euler's three great fundamental equations of the classical hydrodynamics the one for vertical motion of a fluid in a gravitational field may be written

$$\frac{dv}{dt} = v\,\frac{dv}{dy} = -g - \frac{l}{\rho}\,\frac{\partial p}{\partial y}$$

The dimensional homogeneity of this equation obviously demands that the dimensions of $\frac{vdv}{gdy}$, and $\frac{vdv}{dy} \cdot \frac{\rho}{\partial \rho/\partial y}$ be unity, and therefore that the dimensions of all combinations of the forms v^2/gl and $\rho v^2/p$ be unity. This fact, or its essence, must have been so self-evident in Euler's mind that it seems unfair to ascribe the discovery of either of these two dimensionless groups to a later investigator. Since custom has attached the name of a modern, Froude, to the first group it seems but fair that Euler should at least receive belated recognition for the second.

HAROLD A. THOMAS.[5]

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[5] Professor of Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

American Patent System

TO THE EDITOR:

As a patent attorney and as an inventor I read with great satisfaction the paper by Dean A. A. Potter[6] in the February, 1943, issue of MECHANICAL ENGINEERING.

A proof that a patent system is an essential part of any government interested in the welfare of its people may be the fact that such radically new types of government as the Soviet organization also maintain a similar expedient to encourage inventors; and Germany, on May 5, 1936, issued a revised patent law which stressed assistance to the poorer inventors and protection of the government and of the people against exploitation of patent rights contrary to the interests of national defense and the welfare of the people.

On July 15, 1933, the following law was enacted by the German government: "Tax privileges and relieves are approved by the ministry of finance when establishing enterprises which pursue the development of new manufacturing methods or of new products. These enterprises, however, may not directly compete with existing enterprises."

In the United States, the inventor, for income-tax purposes, must spread his expenses for securing patent protection, attorney's fees, drawings, models, and development and experiments over the period of time during which the patent is valid. These deductible expenses are all crowded around the time when the invention is made, and it is during this time that the inventor needs financial assistance and not during the, maybe 16, years thereafter when we wish him to receive a reimbursement for his labors. He has little relief at the time when he must gamble, perhaps, all he has; when he does not know whether he will obtain a patent; and when he cannot materialize much from his invention because at that time it is usually not possible to estimate the actual value of the invention. The inventor can charge the aforementioned costs against income from royalties. When he has such income, payment of taxes does not worry him much. He needs relief to the greatest extent at the time when the "baby" is born and brought up to maturity and not when it is already in a position to repay the expenses of its originator. Aside from this, bookkeeping is much simpler when the expenses are deducted when and as they are had.

United States Patent Office fees are low as compared with those of other countries where annuities must be paid to maintain a patent. Nevertheless, for the small inventor, the filing fee, which he must pay at a time when he has no idea at all as to whether he will receive a patent, is very often quite a burden and it may be worth while contemplating whether the filing fee could not be reduced and the final fee increased by the same or even a larger amount. At the time the final fee becomes due the expenses for prosecuting the patent application are out of the way and the inventor knows that he obtains a patent. He also has a much clearer idea as to the value of his invention and he may even have already earned money on it, so that payment of a higher final fee will be no great hardship.

There is the great uncertainty in the United States patent system that for the whole life of the patent nobody knows whether the patent is valid or not unless it has been contested in one or more courts. This matter has a discouraging effect on most inventors and the users of an invention. He and they should, at least after a certain period of the life of the patent, say, 5 or 7 years, be assured that from now on the patent cannot be invalidated. The testing of the validity should not be left to courts more or less inexperienced in such matters but should be in the hands of an office which is especially set up for this purpose and could be annexed to the Patent Office. It would remove uncertainties so detrimental to the building up of new industries and it would be a great relief to manufacturers interested in the invention if it could be found out in a relatively short time whether a patent which may be in the way is invalid or whether it would be better to negotiate a license agreement with the patentee. It is believed that the possibility of opposing a patent within a certain period of time from its grant, in an office as suggested, would be of great help.

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[6] "The Pride of America," by A. A. Potter, MECHANICAL ENGINEERING, February, 1943, pp. 133–134.

A lot has been heard recently to the effect that our patent system carries the benefits of ownership just a little too far. There appears to be something to this.

If it is possible in other countries, for example, Canada, to force a patentee who tries to benefit too much from his property or prevents any benefit to anybody else to grant licenses at reasonable rates, it should be possible to find similar means in our country without wholly destroying something which, if used right, is an invaluable asset. No community-minded patentee would consider this an infringement on his rights and I am sure it would be welcomed by all parties concerned. It is a fact that in countries where compulsory licenses may be granted it is seldom necessary to enforce the particular law, because its mere existence prevents undue use of the well-earned rights of the inventor.

The American patent system is fundamentally sound and has many advantages over other patent systems. Its beneficial effect on the life of our nation is so great that it is well worth while to assist and promote it by suitably devising bordering laws, such as tax laws and Patent Office rules. Because it is so fundamentally sound it can stand minor operations which may become advisable from time to time to adapt it to changing economic and social conditions and it will benefit thereby.

K. A. MAYR.[7]

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[7] Patent Attorney, New York, N. Y. Mem. A.S.M.E.

Interpreting Water Analyses

TO THE EDITOR:

An article[8] in the October, 1942, issue discusses a chemists' perplexity under the title, "Ions, Parts per Million, and Equivalents per Million." To the extent that the chemists were perplexed as to a universal mode of expressing analytical results, the action of the A.S.T.M. Committee, as described in the article, probably accomplished its objective. If industry's only interest in a water analysis was a knowledge of what the water contained, the committee could feel satisfied it had resolved a complicated issue.

Actually, the committee's action simplifies a complicated issue by ignoring its complexities. Our real interest in water analysis is to learn something of the behavior characteristics of the water as a boiler feed and to permit determination of suitable procedures to counteract the deleterious effects the untreated water would have when so used. From the viewpoint of pure science, the committee may be absolutely right in stating that, in dilute solutions, such as ordinary water supplies, the dissolved substances are transformed from compounds into ions. From the viewpoint of the utility of a water, the important fact is that the impurities do not stay in solution, but, as concentration occurs within the boiler, certain compounds are precipitated. When the engineer saws open a cross section of a burned-out tube and notes the thickness of the encrusted scale, it is small comfort to him to reflect that in its previous history scale had been in ionic solution.

In one of the most recent publications in the field of water chemistry, Schroeder and Berk[9] have done a notable piece of work and have contributed some very valuable data on what was one of the least understood phases of boiler chemistry. In their work, these authors constantly refer to water analyses. Every water analysis in the bulletin is reported by compounds, not by ions.

It would seem that, if progress is to be made in the interpretation of water analyses, the difficult matters should be probed, not ignored. For instance, why should not we by now have results of research to show the order of precipitation of compounds as concentration proceeds? If chemists cannot tell us what compounds are present in water, why cannot they tell us what compounds are formed when the water evaporates? Have the methods of microscopic crystal analysis been applied to the residues from evaporation? What about selective solubility in various solvents applied to these residues as a means of determining what compounds exist in the residue?

The writer would like to ask whether any water chemist can attempt to discuss an ionic water analysis without promptly using his own notions as to probable combinations.

MELVIN BELL.[10]

CLOSURE[11]

The A.S.T.M. Committee D-19, on Water for Industrial Uses, recognized the need for a rational system for reporting the results of water analysis and prepared its standard, suggesting the ionic form, because of the lack of scientific data on solubility of substances in water. The ionic method of reporting water analysis is a means for writing down in numbers what the analyst finds. It is obviously desirable to have all chemists use one method of reporting rather than the numerous schemes now in current use. Once a suitable standard is developed it will facilitate all further work to determine what the dissolved solids will do under any given set of practical conditions. The solubility data are necessary in order to report the water analysis in molecular form particularly if the method is to have any scientific value. For natural water it is necessary to have the solubility for the temperature range from the freezing to the boiling points at atmospheric pressure, and for water undergoing evaporation, that such data be available for operable pressure and temperature conditions.

Several investigators have suggested attention to equilibria conditions.[12,13] A vast fund of information is required for the simple and complex salts the latter forming as the dilute salines produce precipitated products on the heat-absorbing surfaces. When the solubility data are provided, then it will be possible to furnish an interpretation of the results of the analysis in molecular form based on scientific data. Such an interpretation will very likely apply only to a limited set of conditions of use of a given water supply. For a different set of conditions an entirely different interpretation may be necessary. For these reasons, as pointed out by Mr. Adams, the report of water analysis should make no attempt at an interpretation of results.

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[8] "Ions, Parts per Million, and Equivalents per Million," prepared by Max Hecht, chairman A.S.T.M. Committee D-19, on Water for Industrial Uses, MECHANICAL ENGINEERING, October, 1942, pp. 742–743.

[9] "Intercrystalline Cracking of Boiler Steel and Its Prevention," by W. C. Schroeder and A. A. Berk, Bulletin No. 443, U. S. Bureau of Mines, 1941.

[10] St. Paul, Minn. Jun. A.S.M.E.

[11] Closure prepared for A.S.T.M. Committee D-19 by Max Hecht, chairman.

[12] "The Calculation of Equilibria in Dilute Water Solutions," by D. S. McKinney, Proceedings, A.S.T.M., vol. 39, 1939, p. 1191.

[13] "A Physico-Chemical Study of Scale Formation and Boiler-Water Conditioning," Carnegie Institute of Technology, Pittsburgh, Pa., Bulletin No. 24, 1927, pp. 138–141.

The Committee is attacking the problem of interpreting the analysis in an indirect manner. It is investigating the possibilities of determining the composition of precipitated products, produced from the evaporation of water under pressure and at specific temperatures, using macro- and microchemical analytical methods, and then identifying the materials using the polarizing microscope, as well as spectrographic and X-ray analysis. In addition it is starting on a procedure for determining the characteristics and behavior of water, using specific methods of testing. Should this approach to the problem provide any promising data, it may then be possible to amplify the current standard method for reporting the results of water analysis by using a system of molecular form.

It would appear that the use of the molecular form for expressing the results of water analysis, as referred to in Bulletin No. 443, was prompted by the authors' use of synthetic solutions of salts. Should the discusser take the opportunity to review the Adams paper, the N.E.L.A. report cited in the paper, and chapter 1, Water and Steam Generation,[14] he would recognize that the ionic form of presenting the analysis lends itself to any desired use that may be made without the necessity of presenting the equations in molecular form.

Hollow Marlin Spike

TO THE EDITOR:

The cover illustration of a recent issue[15] shows men using "marlin spikes."

In Franklin, Pa., years ago, when we used rope drives, British system, we had to shorten the ropes occasionally.

In resplicing, we used a marlin spike consisting of a piece of steel drilled out to leave a thin wall. This was thrust between strands where the end of a strand was to be inserted. The end was then slipped into the barrel or tunnel, far enough to extend beyond the strands it was to pass between. The spike was then pulled on through, leaving the strand ready to be pulled taut.

We found that the work could be accomplished much more rapidly with this form of marlin spike than with the old-fashioned type, and the strands did not have to be pried so far apart to get the end of the strand through.

This suggestion might be of some use today. The idea of the marlin spike did not originate with the writer but was a contribution of one of the workmen. Unfortunately, his name cannot now be recalled. Many such clever ideas were conceived by the rank and file, all of which contributed to our efficiency.

M. W. SHERWOOD.[16]

Domestic Oil Heating

COMMENT BY D. W. NELSON[17]

This paper[18] shows that the efficiency of burners was such that they averaged 7.35 per cent CO_2 and 599 F flue-gas temperature in 1937, and 8.72 per cent CO_2 and 553 F in 1941–1942, which is in the direction of improvement. A similar survey[19] was made some years before in Madison, Wis., in an effort to call attention to the factors influencing efficiency. On 141 installations, with no changes in adjustment, the average CO_2 was 7.8 per cent and the flue-gas temperature was 634 F, which are quite close to the figures for the 1937 survey of this paper.

In the Madison survey, a separation of installations made during the three-year period, immediately preceding the survey and earlier, showed no improvement. The poorest installation found showed 4.6 per cent CO_2 and 780 F and the installer was considering cutting an auxiliary opening for secondary air. It does not seem to be generally recognized that the flue-gas temperature increases with increased excess air. At the time of this Madison survey only seven factory-built units were available for test; the average CO_2 was 9.3 per cent and the flue-gas temperature was 529 F. Two units of one manufacturer showed 7.2 per cent CO_2 and 445 F, and four units of another, 11.3 per cent CO_2 and 629 F.

The general impression has been that a factory unit as against a conversion unit will give high efficiency. Both are governed by the same laws, which call for an efficient combustion system and ample efficient heating surface. To keep first costs down, many factory units installed were undersized as to heating surface.

In the early days, the most serious fault was overfiring because the installer and customer believed in ample capacity, and because it was difficult to build and adjust a burner for capacities to match heat losses. In this early period, many round boilers with little indirect heating surface and with hardly sufficient capacity for coal burning were converted to oil with resulting high fuel costs.

Heating surface is most important in an oil burner, because the heat release is usually at the maximum rate when operating, as against the widely varying rate when hand-fired with solid fuel. Ample and efficient heating surface is the prime requisite, as an installation with low fuel-gas temperature can have high efficiency in spite of low CO_2, as shown in Fig. 25 of the paper. The writer is glad to see the statement made and Fig. 26 given, showing that the efficiency was highest for the greatest length of operating time. A similar statement was also made in the previous paper,[19] and the same fact was demonstrated in Fig. 2 of that paper. The accuracy of the statement was quite generally disputed in 1935.

Report of 1942 Business Meeting

TO THE EDITOR:

The summary in the January issue of MECHANICAL ENGINEERING of the action of the Annual Meeting on my resolution is unfortunate in what it fails to say.

I said definitely then that I was not asking now for the publication of my paper. I did present a resolution stating the devotion of the Society to high professional standards, the desire of the Society to serve their fellow men without partisanship, and the nurture of its members in the scientific tradition of discussion without censorship of all controversial subjects.

The resolution I presented then asked for the appointment of two special committees, one to set up procedure for the highest standards and thoroughness in consideration of appeals by members to the Council, and the other to set up procedure to insure the presentation before the Society without delay or censorship of papers on controversial economic engineering subjects.

On this resolution, the annual meeting took no action.

A copy of my prepared address and a copy of the resolution were mailed to the Secretary on November 30.

In fairness to me and the thousands of members of the Society who were not present at the annual meeting this statement of what I did should be published.

GREGORY M. DEXTER.[20]

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[14] "Chemistry of Engineering Materials," by R. B. Leighou, Chapt. 1, Water and Steam Generation, McGraw-Hill Book Co., 1942.

[15] MECHANICAL ENGINEERING, January, 1943.

[16] Chicago, Ill. Mem. A.S.M.E.

[17] Associate Professor of Mechanical Engineering, University of Wisconsin, Madison, Wis. Mem. A.S.M.E.

[18] "Twenty Years of Progress in Domestic Oil Heating," by R. J. Bender, MECHANICAL ENGINEERING, October, 1942, pp. 731–740.

[19] "Oil-Burning in Residences," by D. W. Nelson, Trans. A.S.H.V.E., vol. 41, 1935, pp. 355–374.

[20] Scarsdale, N. Y. Mem. A.S.M.E.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Food for Thought

Food for Thought. By H. F. Willkie and P. J. Kolachov. Indiana Farm Bureau, Inc., Indianapolis, Ind., 1942. Cloth, 6 × 9 in., 209 pp., illus., $2.

Reviewed by Huber O. Croft[1]

"FOOD for Thought" has been written to stimulate the interest of farmers and the general public in alcohol fuel from farm products to be used in internal-combustion engines on the farm.

The first pages explain that some 35,000,000 acres were taken out of cultivation due to the replacement of draft animals by tractors and trucks and that it is possible for this land to be brought back for the cultivation of alcohol crops, provided it proves a profitable venture for farmers. The point is made that the richness of the soil may be undisturbed as the nitrogen and minerals of the soil removed with the crops are returned to the soil with the fertilizing waste products of the alcohol plant.

Community alcohol plants located where the maximum haul of crops is not more than 25 miles are advocated in which 95 per cent alcohol is to be made with a contemplated efficiency of 92 per cent of conversion of starch to alcohol. It is proposed that the money for the plants be borrowed from the Federal Government and that the debt can be amortized in a ten-year period. Descriptions of the proposed plants and the methods of operation are given for utilizing grains, sugar beets, Irish potatoes, and sweet potatoes.

Ninety-five per cent alcohol is recommended as fuel instead of a blended mixture of gasoline and alcohol. This would necessarily require redesign of engines and carburetors in order to permit the higher compression ratios at which alcohol would be used most advantageously.

An estimate is made that a 10,000-gallon per day plant using 63-cent corn can produce 95 per cent alcohol at 28.5 cents a gallon. Since gasoline has approximately 127,000 Btu per gal and the alcohol has 80,800 Btu per gal, one could afford to pay approximately 45 cents per gallon for the gasoline for equal calorific value. If, on the other hand, waste raw materials are used for which no charge is made, the cost of the 95 per cent alcohol is claimed to be 6.83 cents per gallon (comparable to gasoline at 11 cents a gallon). One important factor which has been omitted in the discussion of the economics of the situation is the question of Federal and State taxes. A review of the use of alcohol and alcohol-gasoline blends in other countries is given together with the work done on antiknock agents.

The appendix includes tables showing the land needed to produce alcohol fuel crops in various states, together with costs of production in various sections and descriptions of certain continuous processes proposed for the distilleries.

Books Received in Library

Aerial Navigation (Flight Lesson Text No. 41). By W. E. Dyer. American Technical Society, Chicago, Ill., 1942. Paper, 6 × 9 in., 64 pp., illus., diagrams, charts, tables, maps, $0.75. The method of aerial navigation called dead reckoning is thoroughly explained in this practical text. Many diagrams and illustrations are used to depict just how the process works. Actual problems with solutions and a set of review questions are included.

oE ✓ Aircraft Drafting Room Manual. (Cadet Series.) By J. G. Thompson. Aviation Press, San Francisco, Calif., 1939, paged in 8 sections. Paper, $9^1/_2$ × $11^1/_2$ in., illus., diagrams, charts, tables, $3.50. The purpose of this book is to supply information on the general requirements for airplane drawings and adequate reference information for preparing them, and to explain the operation of the drafting-room system used in most aircraft factories. Part one describes drafting practices, based upon the requirements of the Army Air Corps. Part two discusses the organization of an engineering office and the establishment of a system for handling drawings. Part three contains data upon the materials used in aircraft.

cE Aircraft Spot and Seam Welding. By G. Kuntz. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1942. Cloth, $5^1/_2$ × $8^1/_2$ in., 108 pp., illus., diagrams, charts, tables, $1.25. The theory and practical operation of spot and seam welding equipment are concisely presented in this small volume. The object is to enable the welder to understand his machine and to provide the aircraft designer with information that will enable him to utilize these welding processes to the best advantage.

Air Raid Precautions Training Manual No. 3 (first edition). Rescue Service Manual. His Majesty's Stationery Office, London, England, 1942. Paper, 6 × 10 in., 149 pp., illus., diagrams, tables, obtainable from British Library of Information, New York, N. Y., $0.45. The organization of a rescue service, the equipment needed, the methods to be used, and the training of rescue teams are set forth in considerable detail in this practical manual. The book is based on British air-raid experience.

Air Raid Precautions Handbook No. 4A (second edition). Decontamination of Clothing, Including Anti-Gas Clothing and Equipment, from Persistent Gases. His Majesty's Stationery Office, London, England, 1942. Paper, 5 × 7 in., 31 pp., tables, obtainable from British Library of Information, New York, N. Y., $0.10. Precise directions are given for decontamination of clothing and personal belongings of all kinds.

Air Raid Precautions Handbook No. 13 (first edition). Fire Protection for the Guidance of Occupiers of Factories and Other Business Premises. His Majesty's Stationery Office, London, England, 1942. Paper, 6 × $9^1/_2$ in., 91 pp., diagrams, charts, tables, obtainable from British Library of Information, New York, N. Y., $0.30. This pamphlet brings together much practical information on the measures to be taken for dealing with fires following air raids and is based on English experience in recent years.

Air Raid Precautions Training Manual No. 1, (first edition). Amended reprint, August, 1942. Basic Training in Air Raid Precautions. His Majesty's Stationery Office, London, England, 1942. Paper, $5^1/_2$ × $8^1/_2$ in., 57 pp., illus., diagrams, tables, 6d, obtainable from British Library of Information, New York, N. Y., $0.15. This is the first of a series prepared by the British Government to further uniform practical training of air-raid precautions personnel. The present manual sets out the basic principles of personal protection against air attack and is intended to cover the first stage of training for air-raid-precautions workers. Protection against incendiary bombs, high explosives, and gas are explained and the elements of first aid are set forth.

A.S.T.M. Standards on Coal and Coke, prepared by Committee D-5 on Coal and Coke. Sampling Methods, Chemical Analysis, Methods of Testing, Specifications and Classifications, Definitions of Terms. September 1942, American Society for Testing Materials, Philadelphia, Pa. Paper, 6 × 9 in., 122 pp., illus., diagrams, charts, tables, $1.35. The methods of coal and coke approved by the Society and the official definitions and specifications for classifying coals by rank and grade are collected in convenient form in this pamphlet.

American Student Flyer. By M. C. Hamburg and G. H. Tweney. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1942. Cloth, $5^1/_2$ × 9 in., 692 pp., illus., diagrams, charts, tables, $1.50. This text is designed for use in high school where preliminary training is offered to boys who intend to apply for appointments to Army and Navy flying corps. The aim has been to provide all the material needed for these preflight courses in a single volume.

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[1] Head of Department of Mechanical Engineering, University of Iowa, Iowa City, Iowa. Manager, A.S.M.E.

Arc Welding Job Training Units. (Dunwoody Series Welding Training Jobs), 103 pp. Gas Welding Job Training Units. (Dunwoody Series Welding Training Jobs), 92 pp. American Technical Society, Chicago, Ill., 1942. Paper, $8^{1}/_{2} \times 11$ in., illus., diagrams, \$1.25 each. These manuals present a course in welding with the electric arc and with gas, adapted to the needs of industrial schools and apprentice training. Each course consists of forty jobs, an information sheet being furnished for each. Question sheets are also provided for most jobs. The courses have been thoroughly tested in schools and industries.

Audels Mathematics and Calculations for Mechanics, a ready reference. By F. D. Graham. Theo. Audel & Co., New York, N. Y., 1942 reprint, Sections A, B, C, D. Fabricoid, $5 \times 6^{1}/_{2}$ in., 700 pp., illus., diagrams, charts, tables, \$2. Section A of this reference manual constitutes an elementary text on mathematics covering simple arithmetic, plane, solid, spherical, descriptive, and analytical geometry, trigonometry, and algebra, with a brief introduction to the calculus. Sections B and C deal with practical electrical and mechanical calculations. In Section D the principle and applications of the ordinary slide rule are explained.

Die Casting for Engineers. New Jersey Zinc Co., New York, N. Y., 1942. Cloth, $6 \times 9^{1}/_{2}$ in., 148 pp., illus., diagrams, tables, \$1. This is a brief practical account of the method and its uses. The principles of the process, the alloys used, the design and construction of dies, finishes for castings, specifications, tests, etc. are discussed.

Engineering Drawing. By L. M. Sahag. Ronald Press Company, New York, N. Y., 1942. Cloth, $6^{1}/_{2} \times 10^{1}/_{2}$ in., 394 pp., illus., diagrams, charts, tables, \$2.75. The aim in this text has been to offer a basic course which will be complete and thorough in subject matter and also closely articulated with industrial standards and practice. The text is divided into three sections of increasing difficulty; fundamental requirements are taught first. A wide selection of problems is included.

Engineering Mechanics, a Textbook for Engineering Students. By B. B. Low. Longmans Green & Co., London, England, New York, N. Y., and Toronto, Canada, 1942. Cloth, $5^{1}/_{2} \times 8^{1}/_{2}$ in., 252 pp., diagrams, charts, tables, \$4.50. This book is chiefly concerned with kinematics and dynamics, including instantaneous centers, velocity and acceleration diagrams, analysis of cams, motion of rigid bodies in two dimensions, and vibrations of various kinds. A chapter is devoted to dimensions and dynamical similarity. Although complete in itself, the book is intended as a companion volume to D. A. Low's "Applied Mechanics."

Essential Mathematics for Skilled Workers. By H. M. Keal and C. J. Leonard. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1942. Cloth, $5 \times 7^{1}/_{2}$ in., 293 pp., illus., diagrams, charts, tables, \$2. Provides a concise review covering the computations used by workers in applied science. Intended for shopworkers, students without college training, and those wishing a practical reference book.

Ferrous Production Metallurgy. By J. L. Bray. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1942. Cloth, $6 \times 9^{1}/_{2}$ in., 457 pp., illus., diagrams, charts, tables, maps, \$4. An unusually successful attempt to cover the production of iron and steel in a volume of moderate size is provided by this text. The current processes are described in some detail and the fundamental theories underlying them are presented. Excellent line drawings are used as illustrations. The treatment is thoroughly up to date. Bibliographic references accompany each chapter.

Flow of Heat in Metals. By J. B. Austin. American Society for Metals, Cleveland, Ohio, 1942. Cloth, $6 \times 9^{1}/_{2}$ in., 144 pp., illus., diagrams, charts, tables, \$2.50. Contains five lectures intended to present the basic principles of heat flow in metals in a nonmathematical way. The nature of heat, the factors that affect the thermal conductivity of metals, the basic laws of heat conduction, and the flow of heat are discussed. Each lecture has a bibliography.

Galvanómetro de Resonancia. (Publicación No. 5, 1942.) By S. Gerszonowicz. Instituto de Electrotécnica, Facultad de Ingenieria, calle Cerrito 73, Montevideo, R. O. del Uruguay. Paper, $6^{1}/_{2} \times 9^{1}/_{2}$ in., 45 pp., diagrams. This pamphlet presents the theory of the vibration galvanometer, discusses its uses, and describes the various types that have been devised. A note on the telephone is appended.

Goals for America, a Budget of Our Needs and Resources. By S. Chase. The Twentieth Century Fund, New York, N. Y., 1942. Cloth, $5^{1}/_{2} \times 8$ in., 134 pp., tables, \$1. In this little volume the Twentieth Century Fund presents an exploratory report in which the author lays down some economic specifications for the postwar United States. Our needs and resources are catalogued with respect to basic wants such as food, shelter, clothing, health, education, and public works. Intended for the general reader.

✓ Heat. By J. M. Cork. Second edition. John Wiley & Sons, Inc., New York, N. Y., 1942. Cloth, $6 \times 9^{1}/_{2}$ in., 294 pp., diagrams, charts, tables, \$3.50. This well-known text covers temperature and its measurement, specific heats, thermal expansion, the transfer of heat, radiation, the first law of thermodynamics, the state of matter, elementary thermodynamics, and the production of high and low temperatures. This edition has been revised to include references to recent advances in the subject of heat and has also been adapted to students with less preparation by increasing the amount of descriptive matter.

✓ Industrial Inspection Methods. By L. C. Michelon. Harper & Brothers, New York, N. Y., and London, England, 1942. Cloth, 8×11 in., 389 pp., illus., diagrams, charts, tables, \$3.50. A course of instruction prepared for use in training junior inspectors for the War Department. The book describes the principles, construction, and uses of the various instruments for dimensional control, for testing physical properties, and for surface inspection. A chapter on the organization of inspection departments is included.

Jig and Fixture Design. Edited by F. D. Jones. Third edition. *Machinery* (The Industrial Press), New York, N. Y., 1942. Fabrikoid, $6 \times 9^{1}/_{2}$ in., 382 pp., illus., diagrams, tables, \$3. The principles underlying the design of various classes of jigs and work-holding fixtures are dealt with, and many ingenious designs used in modern shops are illustrated.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by A.S.M.E. members for a small handling charge. The Library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Harrison W. Craver, Director, Engineering Societies Library, 29 West 39th St., New York, N. Y.

Jordanoff's Illustrated Aviation Dictionary. By A. Jordanoff. Harper & Brothers, New York, N. Y., and London, England, 1942. Cloth, 7×10 in., 415 pp., illus., \$3.50. This dictionary gives clear definitions of some two thousand aeronautical terms and illustrates each by a simple drawing. Slang terms are included. Should prove a popular addition to any collection on aviation.

Lubrication. By A. E. Norton, edited by J. R. Muenger. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1942. Cloth, $6 \times 9^{1}/_{2}$ in., 244 pp., diagrams, charts, tables, \$3. This book is intended to meet the need for a basic text covering the fundamental principles that underlie the rational design of machine bearings and the methods of lubricating them. Starting with the simple concepts of viscosity and laminar flow, the major part of the book is devoted to developing the hydrodynamic theory of bearings. The types of friction of interest in lubrication are also discussed and criteria for bearings are given. Lubricants are considered. Plain bearings are compared with roller contact bearings.

✓ MacRae's Blue Book, America's Greatest Buying Guide, and Hendrick's Commercial Register, 50th Annual edition, 1942–1943. MacRae's Blue Book Co., Chicago, Ill., and New York, N. Y., 1942. Cloth, $8 \times 11^{1}/_{2}$ in., 3728 pp., illus., \$15. The latest edition of this well-known directory follows the pattern of the previous one but has been thoroughly revised. An excellently classified subject directory is provided to manufactures of all kinds, accompanied by a directory of manufacturers and local distributors. There is also a large index of trade names.

Manual of Explosives, Military Pyrotechnics and Chemical Warfare Agents. By J. Bebie. The Macmillan Co., New York, N. Y., 1943. Cloth, $5^{1}/_{2} \times 8^{1}/_{2}$ in., 171 pp., diagrams, tables, \$2.50. This manual is a convenient source of information on the composition, properties, and uses of explosives and war chemicals. The articles are arranged in alphabetical order, with cross references to service symbols, trade names, and other synonyms. Composition, properties, and uses are stated concisely. There is a bibliography.

✓ Motion Study for the Supervisor. By N. R. Bailey. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1942. Cloth, 5×8 in., 111 pp., diagrams, charts, tables, \$1.25. The object of this little book is to explain the basic principles of motion economy as simply and logically as possible, including a method of observation that permits an operation to be studied easily. The work is intended for foremen and aims to give them a sound and sympathetic understanding of motion-study principles.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

A.S.M.E. Spring Meeting to Be Held at Davenport, Iowa, April 26–28, 1943

Three-Day Program Is Built Up Around Aviation, Management, and Production Problems

PLANS are well advanced for the program of the 1943 Spring Meeting of The American Society of Mechanical Engineers to be held in Davenport, Iowa, April 26–28, 1943, with sessions sponsored by the Aviation, Fuels, Heat-Transfer, Power, Management, Production Engineering, and Wood Industries Divisions. Headquarters will be at the Blackhawk Hotel.

Aviation

The Aviation Division is particularly proud of its papers which have of course been selected primarily to show the unbelievable progress made in this field for our war program.

At the first of the aviation sessions there will be papers by John P. Morris, director of the war aviation training program in colleges, on "Work of Civil Aeronautics Administration in the War Effort," and by J. A. Herlihy, vice-president, United Airlines, on "The Future of Air Transport." The second session which is co-sponsored by the Production Engineering Division will feature a paper by Igor Sikorsky on "The Sikorsky Helicopter." This paper, accompanied by flight films, will be presented by Prof. John E. Younger, secretary of the Division. The second paper for this session, also with films, will deal with the manufacture of aviation engines and will be presented by H. E. Linsley, director of public relations of the Wright Aeronautical Corporation.

Registration Fee for Non-Members at the 1943 Spring Meeting

There will be a registration fee of $2 for nonmembers attending the 1943 A.S.M.E. Spring Meeting at Davenport, Iowa, April 26–28, 1943. For nonmembers wishing to attend just one session the fee will be $1. This is in accordance with the ruling of the Standing Committee on Meetings and Program.

Members wishing to bring nonmember guests may avoid this fee by writing to the Secretary of the Society before April 16 asking for a guest-attendance card for the Spring Meeting. The card, upon presentation by a guest, will be accepted in lieu of the registration fee. Guests are limited to *two per member.*

Finally, at the aviation luncheon it is planned to have as speaker Major Nathaniel F. Silsbee of the air-information section of the news division of the Bureau of Public Relations. Major Silsbee is well known as an excellent as well as an authoritative speaker, so this will be no luncheon to skip.

Management

The Management Division also has ambitious plans afoot. Its first session schedules a paper on "Planning and Control Procedures Which Aid War Production" to be delivered by Capt. J. W. Karraker of the Chicago Ordnance District of the War Department. Colonel Crosby Field is also on the program with a paper on "The Safety and Security Branch of the Ordnance Department."

At an evening session of the Division Dr. Arthur Steindler, outstanding orthopedist, will talk on what biokinetics has to offer industry. Dr. Steindler is professor of orthopedics at the University of Iowa and is one of the leading authorities in this country in that field. His talk should prove of immense interest and serve to link the profession of engineering more closely with that of medicine.

At the same session William J. Biehl, supervisor of methods development of Libby, McNeill and Libby, Chicago, Ill., will talk on motion study for factory workers, another topic of great importance at the moment.

Talks are also being arranged to cover the general subject of women in industry and the Division expects to be fortunate enough to secure as speakers Dr. B. I. Beverly, director of health and personnel at the Republic Drill and Tool Company, Chicago, and W. F. Sherman, director of foreman training, at the Rock Island Arsenal.

BLACKHAWK HOTEL, HEADQUARTERS FOR A.S.M.E. 1943 SPRING MEETING

Finally, a dinner meeting is in the making with the general topic for after-dinner talks on "What Management is Contributing to the War Effort" and while we are not permitted at this time to announce the speakers, the tentative line-up is eye-popping.

Power and Fuels

The Fuels Division is planning two sessions but so far titles of papers and authors are not available, although one particular paper may be announced, that by Carl J. Eckhardt, Jr., and C. W. Yates of the University of Texas, on "Lignite—Influence of Storage Conditions Upon Size Degradation, Size Stability, and Friability."

Two sessions are scheduled for sponsorship by the Power Division, one of which will be held jointly with the Main Research Committee of the Society. Papers are planned on turbine washing and the chemical cleaning of boilers.

While the Heat Transfer and Wood Industries Divisions are not able as yet to announce their respective programs, committees assure us that the papers they are gunning for are of the utmost importance—in fact the Wood Industries Division is of the opinion that so much good material is on the fire that a third session may be necessary to present properly their contributions.

Papers on glass gages and milling-machine practice are being lined up by the Production Engineering Division, and the Committee on

Education and Training is all set for sessions on industrial training programs and industrial training techniques.

So, while this is rather a sketchy outline of what you may expect to find on the Spring Meeting program, it is sufficient to make you certain that three or four days spent in Davenport the end of April will not be wasted. There will be no Fall Meeting this year and the Davenport Meeting will be your only chance to attend a national meeting of the Society in the Middle West. The next such meeting is the Semi-Annual Meeting in June, in Los Angeles.

"Where the West Begins!"

Davenport is strategically located for a general meeting—182 miles west of Chicago, 320 miles east of Omaha, 352 miles southeast of the Twin Cities, and 240 miles north of St. Louis. Distances such as these are merely "hops" from a city styled "where the West begins!" It is one of the most important industrial and manufacturing centers between Chicago and the West Coast. There are located the largest agricultural-implement factories in the world together with scores of other plants making an infinite variety of products for national and local distribution. While we are not able to state definitely which of these industries members may expect to visit, there will be certain ones of extreme interest through which inspection trips will be made. As for other recent meetings, members are advised to bring proof of their citizenship if they plan to attend such excursions.

Davenport, Iowa, Moline, Ill., and Rock Island, Ill., form a group known as the Tri-Cities—the name by which the A.S.M.E. Local Section is identified—and it is doubtful if the Society has a more active Local Section than is this one. Committees are hard at work and have been for some time to make of this Meeting one which will set an all-time high for general excellence. Plan to attend.

Actions of A.S.M.E. Executive Committee

At Meeting in Society Headquarters on January 27

A MEETING of the Executive Committee of The American Society of Mechanical Engineers was held at the Society headquarters on January 27, 1943. Vice-Chairman Clarke Freeman called the meeting to order in the absence of H. V. Coes, president of the Society, who took the chair later upon his arrival. There were also present George E. Hulse, C. B. Peck, and A. R. Stevenson, Jr., of the committee; George L. Knight (Finance), W. A. Carter (Professional Divisions), C. E. Davies, secretary, and Ernest Hartford, executive assistant secretary. At 2:30 p.m. John A. Goff and Victor Wichum of the Committee on Professional Divisions joined the meeting.

The following actions of the Executive Committee are of general interest.

Standardization of Steam Turbines

Action, reported in the January issue, relating to the standardization of steam turbines was corrected to read: "To appoint a committee to give consideration to the standardization of the number of, and the pressures at, the points of extraction in steam turbines designed for regenerative feedwater heating." The matter was reported to the Council by A. G. Christie and not by the Committee on Power Test Codes, as was stated in the January issue.

Changes in the Budget

Certain changes in the budget were referred to the Finance Committee.

Production Clinics

The Secretary reported that during the spring, summer, and fall of 1942, seven production clinics were held. The President was asked to send letters of commendation to the local sections who were participating in the second series of these conferences now in progress.

Gantt Medal

The committee voted to accept custody of the Gantt Medal fund and approved the charter and rules of procedure for the Gantt Medal Award as submitted by the Gantt Medal Board of Award.

Annual Meeting Headquarters

On recommendation of the Committee on Meetings and Program, the Hotel Pennsylvania, New York, N. Y., was designated as headquarters for the 1943 Annual Meeting.

New London Section

The name of Norwich Section was changed to New London Section.

Professional Divisions

Appointments of the following officers of divisions were confirmed:

Divisions	*Chairmen*	*Secretaries*
Applied Mechanics	J. H. Keenan	J. N. Goodier
Aviation	R. F. Gagg	John E. Younger
Fuels	H. F. Hebley	D. C. Weeks
Heat Transfer	L. M. K. Boelter	H. B. Nottage
Hydraulic	E. B. Strowger	L. J. Hooper
Management	James M. Talbot	G. M. Varga
Materials Handling	G. E. Hagemann	C. H. Barker, Jr.
Metals Engineering	W. Trinks	R. A. North
Oil and Gas Power	E. S. Dennison	L. N. Rowley, Jr.
Petroleum	W. F. Herbert	W. H. Carson
Power	Theodore Baumeister	J. A. Keeth
Process Industries	William Raisch	T. R. Olive
Railroad	J. R. Jackson	E. L. Woodward
Rubber & Plastics Group	Gordon M. Kline	Robert A. Boyer
Production Engineering	Warner Seely	C. L. Tutt, Jr.
Textile	F. L. Bradley	W. W. Starke
Wood Industries	Sern Madsen	A. C. Fegel

The status of the Committee on Instruments and Regulators of the Process Industries Division was changed to that of a division bearing the same name.

Steam Turbine Test Code

The Secretary was authorized to proceed with the preparation for publication of the Appendix to the Steam Turbine Test Code.

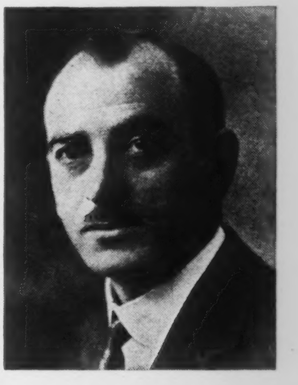
Council

The appointment of Clarke Freeman as vice-president of the Executive Committee was confirmed.

Owing to special duties in China assigned to him by the United States Government, Paul B. Eaton resigned as a manager of the Society. This resignation was accepted with regret and Mr. Eaton was appointed Honorary Vice-President of the Society with special credentials to the Chinese Institute of Engineers.

F. V. Larkin Appointed to the Council

Fred V. Larkin was recommended to the Council to fill the unexpired term of Paul B. Eaton. (Mr. Larkin's appointment was later confirmed by letter ballot of the Council.)



F. V. LARKIN

Group Delegates Conference

Recommendations of the 1942 Group Delegates Conference relating to the Council were considered by the committee, and the other recommendations were referred to the committees interested in them. Comments on all recommendations will be reported to the Council.

The Secretary reported greetings from The Institution of Mechanical Engineers, London, The Centro Argentino Ingenieros, Buenos Aires, and All-Union Society of Machine Building Engineers, Moscow.

Deaths

The following deaths were reported:

H. H. Vaughan, honorary member, Dec. 11, 1942.

E. J. Prindle, honorary member, Dec. 17, 1942.

Harte Cooke, former member of the Council, Dec. 13, 1942.

George B. Karelitz, former chairman of Committee on Professional Divisions, Jan. 19, 1943.

Standardization

Approval was recorded of the adoption as standard practice of the Society of the proposed revision of American Standard for Letter Symbols for Heat and Thermodynamics, Including Heat Flow

Appointments

Appointments reported and not already noted in the 1943 Society Records, Part 1, were:

R. F. Gagg (five years), Committee on Publications.

Wells L. Davis (one year), Junior Adviser, Committee on Constitution and By-Laws.

A.S.M.E. Rubber, Plastics Subcommittee, a Group

BECAUSE of the increased interest in the field of rubber and plastics, the A.S.M.E. Standing Committee on Professional Divisions presented a request to the Council of the Society to have the status of the Rubber and Plastics Subcommittee of the Process Industries Division changed to that of a Group. The Council has approved this change.

The chairman of the new Rubber and Plastics Group of the A.S.M.E. is Dr. Gordon M. Kline, National Bureau of Standards, Washington, D. C., and members of the executive committee serving with him are E. F. Riesing, Firestone Tire and Rubber Company, Detroit, Mich., vice-chairman; Robert A. Boyer, plastics-research department, Ford Motor Company, Dearborn, Mich., secretary; L. E. Jermy, editor, *Machine Design*, Cleveland, Ohio; J. F. Downie Smith, research division, United Shoe Machinery Corporation, Beverly, Mass.; and F. L. Yerzley, Western Electric & Manufacturing Co., Kearny, N. J.

New A.S.M.E. Division on Instruments and Regulators

AT its January 27, 1943, meeting, the Executive Committee of the Council of the A.S.M.E. approved the request of the Standing Committee on Professional Divisions for a change of status from that of Subcommittee on Industrial Instruments and Regulators of the Process Industries Division to that of Division.

The chairman of the new Industrial Instruments and Regulators Division is E. S. Smith, Eclipse Aviation, Bendix N. J., vice-chairman, E. D. Haigler, Foxboro Company, Foxboro, Mass.; and secretary, J. C. Peters, Leeds and Northrup Company, Philadelphia, Pa.

The Division has many subcommittees representing various fields of its work and it is suggested that members of the A.S.M.E. interested in registering with this Division write to Ernest Hartford, executive assistant Secretary, A.S.M.E. Headquarters, 29 West 39th St., New York, N. Y.

Aid Rendered by Boiler Code Committee to Nation's War Program

All Requests for Various Changes in Rules Receive Committee Consideration and Action

MANY of the actions taken by the Boiler Code Committee during the past year and a half have been contributing factors in the general stepping-up of the national war effort. The Committee has received many requests from manufacturers, consumers, and government agencies requesting various changes in its rules, all in the interest of the war program. Every request has received the committee's consideration, followed by appropriate action.

Interpretations of the Code as formulated by the committee are published in MECHANICAL ENGINEERING and are referred to by case number. Interpretations which have materially assisted in the war effort may be separated into two general groups—those that allow a saving in critical materials through an increase in the design stress, and those that assist in increasing production by providing for the use of substitute materials.

Cases 968 and 979 Most Important

The issuance of Cases Nos. 968 and 979 has been the most important contribution of the committee in effecting savings in vital war materials. Under the provision of these cases an increase in stress is permitted for power boilers and unfired pressure vessels provided certain refinements are embodied in the design. A considerable saving in tonnage of steel plate is thus made possible.

It is well known that a serious shortage exists in certain materials. This is particularly true of some of the steel alloying elements. The A.S.T.M. has sought to relieve this shortage in part by replacing certain of its established material specifications with a series of Emergency Alternate Provisions, designed to reduce the specified amounts of these critical alloys. The Boiler Code Committee has co-operated in this effort by accepting those A.S.T.M. Emergency Alternate Provisions which affect Code specifications and this action has been covered by Case No. 981.

Alloy bolting materials have become increasingly difficult to obtain and the Code now recognizes certain substitute materials for this purpose as outlined in Case No. 983. These materials provide adequate safety for the conditions under which they are permitted.

Under the provisions of Case No. 957, ferrous washout plugs may be substituted for those made of nonferrous materials in steel low-pressure heating boilers.

The committee has slightly broadened several of its material specifications and has also made provision for the use of continuous or strip-mill plate in Code vessels. This is covered by Case No. 959 for plate rolled from material complying with Specifications S-1, S-2, S-42, and S-53 and under Case No. 978 for plate rolled from material complying with Bureau of Ships Ad Interim Specification 48S5. As a result, the quantity of material acceptable in Code constructions is effectively increased.

Case No. 984 permits a slight relaxation in the specification requirements of Specifications S-1 and S-2 plate material. The tensile range for these materials has been increased by raising the upper tensile limit. This change will permit material complying with Specification S-1 and material complying with another widely used specification to be taken from the same heat. A small increase in the permissible sulphur, which will not affect the physical properties of the material, will greatly reduce the percentage of mill rejections.

Pars. P-102 and U-68 require one test plate for each drum or pressure vessel welded under the provisions of that paragraph. When a manufacturer is in continuous production of drums or pressure vessels of approximately the same thickness range, it is the opinion that a test plate for each vessel was not necessary and to comply with the requirements was more than needed to warrant safe construction. Case No. 961 was issued to alleviate the condition described, and the reduction in the number of test plates required offers a saving in both critical material and production time.

Inability to obtain forged or cast-steel butt-welding flanges specified on vitally needed pressure vessels has created a serious bottleneck in their production. Shortage of these flanges had become so critical as to unbalance the production schedules of such vessels. The committee has provided in its rules for the fabrication of built-up hubbed flanges and necks by fusion welding, covered by Case No. 985.

Safety Primary Object

The Boiler Code Committee, upon appointment, was charged with the responsibility of preparing rules, the primary object of which is safety. Therefore, the committee must satisfy itself that only safe construction can result when its rules are applied. Consequently, all of the aforementioned modifications in the rules of the Boiler Code have been approved only after they have been carefully reviewed to make certain that safety has been maintained.

The Army Wants Ideas

THE Engineer School, Fort Belvoir, Va., operates a suggestion system which is more than a year old. To date eleven per cent of the suggestions have been put to use. An extensive campaign to promote suggestions has been started. Engineer soldiers are authorized to send suggestions direct without going through other military channels.

Civilians also are welcome to send suggestions. No useful idea is too small to report. Every idea is judged by competent critics; and every suggestion is copied and submitted to the critics without any indication of its source. Approval does not depend on rank or influence.

President's Page

What Do I Get Out of the Society?

WHAT do I get out of the Society? Quite frankly, I am frequently irked by that question. It reveals a lack of imagination of personal responsibility to the engineering profession and further a lack of sense of values. My invariable answer, carefully considered, based not only on my own experience but on that of scores of other members, is, "I get out of the Society just what I put into it (aside from money) in furthering its objectives, in building up the profession, and in service to the public."

I have spent thirty-five years of my life in furthering these aims in one capacity or another and I expect to continue to do so as long as I am able. Furthermore, I have been privileged to make some of the finest friends one could possibly ask for through my association and work in the Society.

You have the opportunity to broaden and strengthen your professional attainments by attending meetings, by presenting or discussing papers, by serving on committees. Bear in mind some of the most important men in this country and in others are members of this Society. They are easy to meet. They are interested in the engineering profession and in the Society and its members. They are particularly interested in the younger members who are ultimately going to take over older members' places in industry and in the Society. So avail yourself of the privileges and opportunities that are yours.

While the work and activities of many of you younger men must of necessity be interrupted and affected by the war effort, I would, nevertheless, like to direct your thinking toward certain opportunities for ultimate service.

1 *Take a greater interest in management and management problems,* not only with respect to those attached to your job but on a broader scale. The Society's Management Division offers many opportunities for improvement of your own understanding and betterment in this field and will welcome your enrollment.

2 *Avail yourself of all opportunities* to understand the basic principles and philosophy of sound industrial relations and labor management, as these problems are in the forefront of management's thinking today.

3 *Attain a clear understanding of the principles* underlying sound and effective organization of an industrial business. Many problems and difficulties stem from this source.

4 *Familiarize yourself with the science and art* of guidance of management through statistical control. Know the range or belt of its probabilities and the application of this art to management control, i.e., control through exceptions.

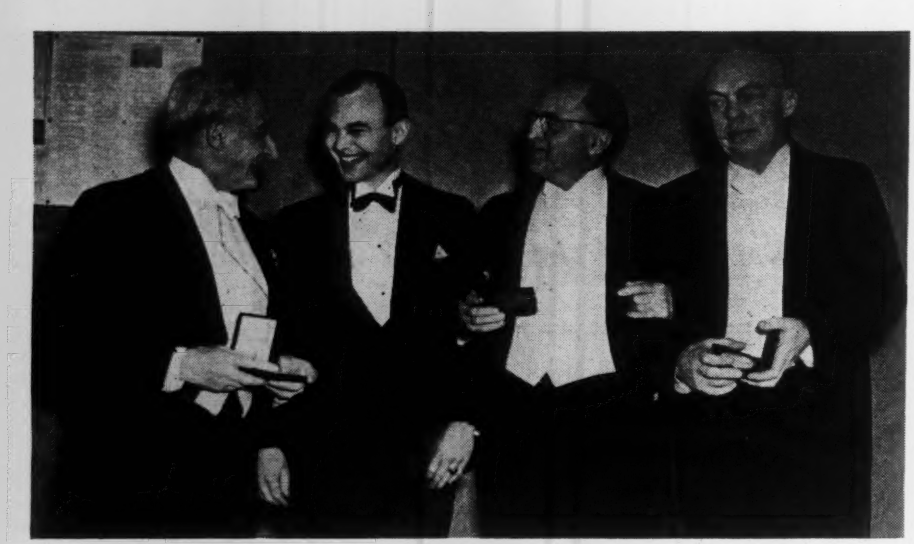
5 *Remember that many small industries,* particularly under present conditions, require management personnel with an engineering background.

6 *We have solved many of the problems* in mass production but not so many in mass distribution. Our technique of mass distribution is far behind our technique of mass production. Many of these problems can be solved by the engineering approach and by engineering technique.

7 *Some of you may have an opportunity* to make a contribution in studies for postwar planning.

8 *Many of you can and should avail yourselves* of the opportunities to serve on the Society's committees.

(Signed) H. V. COES, *President, A.S.M.E.*



PRIZE WINNERS

(When the American Institute of Electrical Engineers met in New York January 27, 1943, for their national technical meeting, three General Electric men and an outstanding radio engineer were honored for the work they had done. At the morning meeting, 31-year-old Dr. George W. Dunlap (second from left), member of the G. E. general engineering laboratory, was awarded the Alfred Noble Prize for 1942. The same evening, Gerard Swope (far left), president of General Electric, was awarded the Hoover Medal for 1942; Dr. Willis R. Whitney (third from left), honorary vice-president of General Electric and former director of the company's research laboratory, was awarded the John Fritz Medal for 1943; and Dr. Edwin H. Armstrong, professor of electrical engineering at Columbia University and developer of FM radio, was awarded the Edison Medal for 1942.)

Midwest Power Conference Chicago, April 8–9

THE Midwest Power Conference will be held on Thursday and Friday, April 8–9 at the Palmer House, Chicago. This conference is sponsored by the Illinois Institute of Technology with the co-operation of nine other Midwestern universities and colleges and eight engineering societies. The co-operating universities and colleges include Iowa State College, Michigan State College, Northwestern University, Purdue University, State University of Iowa, University of Illinois, University of Michigan, University of Minnesota, and the University of Wisconsin. The list of co-operating societies is composed of the Chicago Sections of the A.I.Ch.E., A.I.E.E., A.I.M.E., A.S.M.E., the Illinois Section of the A.S.C.E., the Illinois Chapter of the A.S.H.V.E., the Western Society of Engineers, and the Engineers' Society of Milwaukee.

The preliminary program of the conference will contain, in addition to the opening meeting, sessions on Electrical Distribution, Industrial Power Plants, Plant Protection, Plant Maintenance, Diesel Power, Fuels and Combustion, and Central Station Practice. The latter is sponsored by the Chicago Section of the A.S.M.E.

In addition to the foregoing sessions, the Conference program will include two joint luncheons, one with the Chicago Section of the A.S.M.E., and the other with the Chicago Section of the A.I.E.E. A high light of the conference will be its All-Engineers' Dinner on the evening of April 8, at which Colonel James L. Walsh, Chairman, War Production Committee A.S.M.E., will be the speaker.

Enemy Patents Offered

THE Office of Alien Property Custodian holds for the United States Government about 50,000 patents formerly owned by residents of enemy and enemy-occupied countries and offers these patents for use by American industry.

A pamphlet, "Patents at Work," has been prepared to provide a brief outline of the policies adopted for the administration of these patent holdings. There is also available an index to the classified lists of vested patents for use as a guide in ordering specific sections.

Appley, Director W.M.C.

LAWRENCE A. Appley, Associate, A.S.M.E., and vice-president of Vick Chemical Company, has been appointed executive director of the War Manpower Commission. Under the recently announced reorganizaation of the War Manpower Commission, the executive director holds complete administrative authority over all phases of the staff services, planning, and operations.

A.I.M.E. Honorary Members

AT the regular monthly meeting of the board of directors of the American Institute of Mining and Metallurgical Engineers, held on Thursday evening January 21, at 29 West 39th Street, New York, N. Y., Paul Dyer Merica, vice-president of the International Nickel Company, and Essington Lewis, Australia's recently appointed Director General of Aircraft Production, and Director General of Munitions, were elected to honorary membership.

A. A. Potter Receives Washington Award

A. A. POTTER, past-president A.S.M.E., dean of the Schools of Engineering, and director of the Engineering Experiment Station, Purdue University, has been elected to receive the Washington Award for 1943.

The Washington Award was founded in 1916 by John Watson Alvord "in recognition of devoted, unselfish, and pre-eminent service in promoting the happiness, comfort, and well-being of humanity." It is administered by the Western Society of Engineers on recommendation of a commission representing the American Society of Civil Engineers, the Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the Western Society of Engineers. The first award was made in 1919 to Herbert Hoover.

W. L. Abbott, past-president A.S.M.E., represented the society upon this occasion.

Wolverine Award to C. N. Deverall

AT the annual meeting of the American Society of Refrigerating Engineers held recently in New York City, Charles N. Deverall, Member A.S.M.E., was presented the Wolverine Award for his paper on "Evaporative Condensers." The presentation is made annually for the best technical paper published by thesociety during the year. Mr. Deverall is engineer in charge of research and development at the Buffalo plant of the Niagara Blower Company.

A.I.E.E. Nominations

THE National Nominating Committee of the American Institute of Electrical Engineers has nominated the following candidates for the offices becoming vacant August 1, 1943:

For president: Nevin E. Funk, Fellow A.S.M.E., vice-president in charge of engineering, Philadelphia Electric Co., Philadelphia, Pa.

For vice-presidents: W. E. Wickenden, member A.S.M.E., president, Case School of Applied Science, Cleveland, Ohio; C. W. Ricker, professor and head of school of Electrical Engineering, Tulane University, New Orleans, La.; L. A. Bingham, assistant professor of electrical engineering, University of Nebraska, Lincoln, Neb.; J. M. Gaylord, chief electrical engineer, Metropolitan Water District of Southern California, Los Angeles, Calif.; W. J. Gilson, general manager, Eastern Power Devices, Ltd., Toronto, Ont., Canada.

For directors: C. M. Laffoon, engineering manager, a-c generator engineering dept., Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.; C. W. Mier, engineer, Southwestern Bell Telephone Co., Dallas, Texas; S. H. Mortensen, chief electrical engineer, Allis-Chalmers Mfg. Co., Milwaukee, Wis.

For national treasurer: W. I. Slichter, Fellow A.S.M.E., professor-emeritus of electrical engineering, Columbia University, New York, N. Y.

Among the Local Sections

War Production Conference Held in Peoria by Central Illinois Section

Attendance of 688 Engineers at Seven Sessions Indicates Success and Importance of Conference

SEVEN important engineering and industrial topics, vital to war production, headlined the all-day War Production Conference conducted by the Central Illinois Section of the A.S.M.E., War Production Board, Peoria Ordnance District, and other agencies at the Hotel Pere Marquette, Peoria, Ill., on Dec. 16. Organized at the request of Donald M. Nelson, the conference was open to all engineers interested in production problems.

Among the speakers secured to discuss the various topics were William du Pont Miller, L. V. James, L. W. Lang, Dr. J. C. Wright, Otto Winter, Dr. B. I. Beverly, and others. The conference started in the morning with simultaneous panel meetings on wartime lighting and training aids for war-production workers. At 1:00 p.m. panels on preservation of finished parts for world-wide storage and shipment, and machine maintenance were held. This was followed at 3:00 p.m. by discussions on the subjects of inspection and quality control, and care and salvage of perishable tools and gages.

Following dinner in the evening, engineers numbering 346 took part in the seventh and final session, which covered the topic, "Women in Industry." Mr. Winter, vice-president of the Republic Drill and Tool Co., formerly consultant to the Russian-Soviet Machine Tool Trust and the Cutting Tool Trust, and recently an investigator of all phases of American industrial production, has been able to train and utilize more than 1500 women for shop operations at his company. Such problems as uniforms, safety and accident control, absenteeism, comparative production rates, and work adaptable for women were covered by him. Dr. Beverly, director of personnel for Republic, and a professor at the University of Illinois in addition to being a medical doctor, discussed the psychiatric phases of female industrial workers. Dr. Wright, assistant commissioner for vocational education, U. S. Department of Education, who was in charge of setting up the entire training program during World War I, covered production training methods applicable to women.

American Engineers in the War Topic at Akron Section

THE Jan. 13 meeting of Akron Section featured John H. Van Deventer who spoke on "How American Engineers are Helping Win the War." The speaker, president and editor of *Iron Age*, outlined the tremendous boost that has been given to applied ingenuity by the spur of war. He described accomplishments that have been made by engineers since the outbreak of hostilities at Pearl Harbor, such accomplishments being prophetic for a bright after-the-war future.

Bridgeport Hears About Production Engineering

More than 100 members and guests of Bridgeport Section at the Jan. 25 meeting heard Prof. C. L. Tutt, Jr., of Princeton University, speak on the subject, "Production Engineering in the War Effort." From first-hand knowledge of his topic, the speaker discussed activity in the work of revamping machinery, from that of the automobile to that of ordnance and aviation equipment. He outlined the variety of machines from bench type to that of 500-ton drop presses and multiple-drill machines, with a fantastic number of spindles performing every conceivable operation. His remarks on precision hardening and heat-treating proved a revelation to many.

Oil Situation Featured at Connecticut Sections

"What Can the Engineering Societies of Connecticut Do to Help Thrash Out the Oil and Gasoline Situation?" was the topic of the hour at the Jan. 11 meeting of the Connecticut Sections in New Haven, Conn. A motion was made by John Smith that the secretary write the Connecticut Technical Council asking that steps be taken among all the engineering groups to attempt to clear up this lamentable situation.

Detroit Section Meets With Junior Group

The Jan. 19 meeting of Detroit Section held jointly with the junior members was highlighted by a speech delivered by Robert Ferar on "Development and Application of the Hydromatic Transmission." The speaker told of the history of the transmission and its development over a period of years, of the problems in hydraulic controls and in application to motor vehicles, both heavy and light, and explained the operation of the "brains" of this automatic transmission in detail, exhibiting some of the key parts, cut away so their operation could be seen. The discussion of this paper suggested possibilities in other approaches to the transmission problem, including a variable-level fluid coupling. Efficiency, slip, cost, production problems, and maintenance problems were also discussed.

A.S.M.E. National Nominations

MEMBERS of The American Society of Mechanical Engineers are invited to appear before the A.S.M.E. Nominating Committee at its open meeting on Saturday, May 29, 1943, at the Bismarck Hotel, Chicago, Ill. Any time between 10:00 a.m. and 4:00 p.m on that day the Committee will be glad to hear any member express his views or discuss matters pertaining to the selection of nominees for elective offices in the A.S.M.E. for 1944.

The personnel of the Committee and other pertinent information on nominations was published on page 149 of the February, 1943, issue of MECHANICAL ENGINEERING, and members of the Society are urged to read this over to refresh their memories.

Indiana Members Meet Friends

The purpose of the Jan. 12 meeting of the Indiana Section was a social one. Philip Sprague, president and general manager of the Hayes Corporation, of Michigan City, was the speaker of the evening. The program also consisted of colored travel pictures of Europe in 1937 and a film of the Western U. S. National Parks. After a pleasant evening, members found themselves better acquainted.

Plastics Plays a Part at Ithaca Section

Members and guests of Ithaca Section on Jan. 19 heard Dr. L. M. Currie, of the National Carbon Company, on the subject of "Engineering and Utility Phases of Modern Plastics." The speaker gave an excellent discussion, with charts, of the composition and physical properties of a representative group of plastics. His timely talk was made even more graphic by the display of large samples which he exhibited to prove his points.

Louisville Hears About Machining Technique

An attendance of over 270 engineers characterized the Jan. 15 meeting of Louisville Section. Dr. Max Kronenberg spoke on "Machining With Single-Point Tools." In the course of his address, he showed how proper application of the formula on metal cutting can be used not only by machine-tool designers but by users of tools in determining the most economical speeds, feeds, and cutting tools. From these determinations, charts can be prepared for machine-tool operators. Such a topic is of unending practicality and interest in these times of high-speed war production.

Synthetic Rubber at Ontario

The Jan. 14 Meeting of Ontario Section, attended by more than 113 members and guests, heard E. R. Rowzee, factory manager, Canadian Synthetic Rubber Company, Ltd., cover the history of the development of synthetic rubber, the various types of synthetic rubber now in use, and their current application. He also reviewed the recent developments in the field of synthetic production. This meeting proved to be of unusual interest to all who attended.

Philadelphia Members Apply Themselves to X Rays

"X Rays Applied" was the fascinating topic at the Jan. 26 meeting of Philadelphia Section, attended by more than 125 members and guests. Everett W. Page explained the applications of X rays to the study of engineering materials. He congratulated mechanical engineers for their support of nondestructive testing of metals. He pointed out that the use of X rays makes lighter designs possible. He also mentioned that voltages up to 100 million are now possible for examination of steel up to about 10 inches in thickness.

Plant Protection at Providence

An audience of over 225 members and guest heard R. E. Wilson on the matter of "Plant Protection in Wartime." The speaker, associate manager of the National Bureau for Industrial Protection, illustrated his talk with a motion picture entitled "How Fires Start in Industry" and another called "They're Dropping Incendiaries." These films, loaned by the inspection department of Associated Factory Mutual Fire Insurance Companies of Boston, were explained by A. L. Brown, their chief engineer.

Triple Attraction at Southern California

The Jan. 15 meeting of Southern California Section proved of great interest to the members at large. "Catalytic Cracking" was presented authoritatively by Wright W. Gary, president Filtrol Corporation. He was well equipped to talk upon this topic, having been associated with Continental Mexican Petroleum, Tampico, Mexico, for a number of years. He also acted in the capacity of private consulting petroleum engineer. From 1929 to 1940 he was director of research and assistant to the vice-president in charge of technical sales for the M. W. Kellogg Company of New York. In 1941 and 1942 he was national director of refining, Office of Petroleum Co-ordinator, Washington, D. C.

The second speaker, Alf Hansen, district turbine engineer, General Electric Company, spoke on the subject, "Mercury Vapor Turbines and Unit Mercury Power Plants."

The third speaker, Bruce Wiswall of the Kelite Products Company of Los Angeles, Chicago, and New York, delivered a talk on "The Answer Is pH." This last speaker, in charge of the aircraft department of the Kelite Products Company, is an expert on the surface treatment of metals and was well qualified to deliver valuable information on his topic.

Toledo Technical Societies Meet at University of Toledo

Members of the Toledo Section and allied technical societies at their meeting on Dec. 17 honored the University of Toledo upon the accreditation of its engineering courses. Section members and students met in this joint celebration. Toastmaster E. G. de Coriolis, director of research, The Surface Combustion Co., presided. Messages from the technical societies were delivered by Urban E. Bowes, director of research, Owens-Illinois Glass Company, for A.C.S.; C. L. Proctor, president and general manager, The Toledo Edison Company, for A.I.E.E.; George N. Schoonmaker, city manager, City of Toledo, for A.S.C.E.; Sydney Bevin, chief engineer, Fiske Bros. Refining Company, for A.S.M.E.; and Carl T. Cotter, Toledo Board of Education, for T.S.P.E. A plaque was presented to the University and accepted by Dr. Philip C. Nash, president of the University, and Prof. Delos M. Palmer, dean of the College of Engineering. Following the introduction of the speaker of the evening by Dr. Stephen K. Mahon, the audience listened to Colonel Ivan C. Crawford, who briefly outlined the development of professional standing in the engineering field and pointed out the engineer's debt to the future.

Morris Talks on Helicopters at Western Massachusetts

The Jan. 19 meeting of Western Massachusetts Section, attended by more than 54 members and guests, featured as its speaker of the evening, Charles Morris, of Vought-Sikorsky Aircraft Corporation, Stratford, Conn. He chose as his topic, "Helicopters." Opening his discussion by reviewing the differences between a helicopter and an autogiro, the speaker pointed out that the helicopter is propelled by a rotating windmill on the top of the plane, while the autogiro has two propellers. The helicopter has the further advantage of being able to stop in mid air and remain stationary as well as being able to move frontward, backward, and sideways. The speaker went on to describe in more detail the construction of the craft and outline its future possible uses. A very illuminating motion picture was shown illustrating some of the feats possible with the plane. Following the film, an interesting question period ensued.

With the Student Branches

Cigars at Alabama Poly

CIGARS and cigarettes were passed out before and during the Jan. 18 meeting of ALABAMA POLY BRANCH. Prof. C. R. Hixon was chosen as honorary chairman to fill the vacancy which occurred when Prof. C. H. Long became affiliated with Virginia Polytechnic Institute. General activities of the Branch were discussed and plans were made for future meetings.

ARKANSAS BRANCH featured student members as speakers at the Jan. 4 meeting. Austin Baches gave a talk on autogiros, explaining the features, advantages, and principles of their operation. Accompanying his talk was a scale model of an autogiro and several diagrams and illustrations. Harold Grant talked on the manufacture of glass products, first outlining the history of the glass industry and then covering the method of manufacturing light bulbs and tubing. Robert Peterson gave a talk about a new machine used in the manufacture of cylinder heads, pointing out the main features of the machinery and indicating its method of operation.

CALIFORNIA TECH BRANCH members visited the new Kaiser Steel Mill at Fontana, Calif., on Saturday, Jan. 23. Prior to the visit, at the meeting on Jan. 15, Dr. Clark of the mechanical-engineering department gave a brief description of the plant.

CASE BRANCH held the first meeting of 1943 on Jan. 13. Chairman E. H. Koepke introduced the officers of the Branch and then called upon W. A. Lynam, honorary chairman, to explain to the new men the part played by the A.S.M.E. in the life of a me-

Student Branch Secretaries

Please Note!

REPORTS of meetings and inspection trips must be received at Society Headquarters on or before the sixth of the month in order to appear in next month's issue of MECHANICAL ENGINEERING. For example, all copy received up to March 6 will be in the April issue, etc.

Photographs of student-member groups are always welcome for use in MECHANICAL ENGINEERING. Prints should be preferably glossy and of good contrast. However, send in everything you have and the editorial department will use those it can reproduce.

Publicity is always good for the branch. Clippings from school and local newspapers should be sent in with your reports.

STUDENT GROUP AT NORTH DAKOTA AGRICULTURAL COLLEGE AT END OF ACCELERATED SUMMER TERM JANUARY 25, 1943

chanical engineer and why mechanical-engineering students should join the organization.

C.C.N.Y. Branch reported that it has completed a full term in January and is looking forward to the spring semester when the Branch will play host to the Regional Student Conference. During the past term an ambitious program was planned and carried out. A great majority of the members attended the two dances given; the annual student-faculty smoker is still smoking, and meetings featured student papers.

Cooper Union Branch at the meeting on Jan. 18 showed an informative and instructive film on "Electric-Arc Welding." After which the members and the guests retired to the mechanical-engineering laboratory where the traditional doughnuts and cider were served.

Lack of Heat at Drexel

Members of Drexel Tech Branch voted on Jan. 14 to hold the weekly meetings on Wednesday nights instead of Thursday nights because of heating conditions. Chairman George Darby then introduced the speaker of the evening, Prof. A. W. Grosvenor, who gave an illustrated talk on "War Steels."

Florida Branch met on Jan. 8 to enable the members to hear two papers, "The Processing of Cotton Seed" and "A Coal Pile." In honor of the seniors graduating in mid-term, a senior banquet is to be held by the Branch.

Illinois Tech Branch held its annual smoker on Jan. 14. The affair was a huge success. Ensign John Taussig, U.S.N., was the principal speaker. He showed three movies, "The Navy and Its Ships," "The Battle of Midway," and "The Navy and Its Planes." Following the showing, he spent about an hour discussing and answering questions concerning these films. Following the program, the 150 members and guests adjourned to the student lounge where refreshments were served.

Kentucky Branch on Jan. 15 presented Professor West, head of the mechanical-engineering department, who spoke on the engineering of yesterday, today, and tomorrow. He told all students to return to school after the war. After reading and interpreting the Army and Navy plans for college students, Professor West pointed out the increase in engineering developments up to the present and advised students to give serious thought to what they might do after the war.

Louisiana State Branch elected new officers at the Jan. 11 session to replace those who have joined the armed forces.

120 Attend Maryland Meeting

On Jan. 3, Maryland Branch held its annual joint meeting with the student chapters of the A.I.E.E., A.S.C.E., and the A.S. Ch.E. More than 120 members and guests were present. Films were shown through the courtesy of the N.A.C.A. on safe flying and on its experimental laboratories.

Mississippi Branch held elections for the coming semester on Jan. 5. Prof. D. M. Varnado was redesignated as honorary chairman.

President Coes Visits Missouri

H. V. Coes, President of the A.S.M.E., was the guest of honor on Jan. 14 of the Missouri Branch at the University of Missouri. More than 50 members were present at the luncheon held in honor of President Coes at the Daniel Boone Hotel, Columbia, Mo. Then in the afternoon, an all-school meeting was held in South Engine Hall to hear President Coes discuss for more than two hours the many phases of engineering management, the future of engineering, and the personal qualities found in a good engineer.

Nebraska Branch on Jan. 13, following an election of new officers for the coming term, discussed in short reports by student members such topics as "Possibilities for the Postwar Automobiles" and "Shipping Freight by Air."

Nevada Branch devoted its meeting of Dec. 22 to the election of officers for the coming term.

New Hampshire Branch joined with other engineering organizations on the campus in a dance, appropriately called "Tech Tussle." Prior to the dance on Jan. 16, the Branch held a meeting at which films entitled "Building a Tank" and "Science Rules the Rouge" were shown. The meeting on Jan. 23 featured interesting talks on transportation in the future and on plastics.

A.S.M.E. Student Members' Meetings for 1943

The schedule for A.S.M.E. Student Meetings this spring has been modified because of war conditions. The number of Branches meeting in groups has been greatly reduced and so nearly double the number of meetings will be held. Thereby the distances to be traveled will be considerably shortened. The tentative layout is as follows:

Meeting	*Host*	*City*
Group I (10)*	Rhode Island State College	Kingston, R. I.
Group II (7)	Syracuse University	Syracuse, N. Y.
Group III (11)	C. C. N. Y.	New York, N. Y.
Group IV (11)	To be decided	Philadelphia, Pa.
Group V (7)	University of Virginia	Charlottesville, Va.
Group VI (6)	University of Pittsburgh	Pittsburgh, Pa.
Group VII (5)	To be decided	Toledo, Ohio
Group VIII (3)	Rose Polytechnic Institute	Terre Haute, Ind.
Group IX (5)	University of Tennessee	Knoxville, Tenn.
Group X (5)	Alabama Polytechnic Inst.	Auburn, Ala.
Group XI (8)	Northwestern University	Evanston, Ill.
Group XII (5)	University of Minnesota	Minneapolis, Minn.
Group XIII (6)	To be decided	Kansas City, Mo.
Group XIV (10)	Southern Methodist University	Dallas, Texas
Group XV (8)	Colorado State College	Fort Collins, Col.
Group XVI (5)	University of Washington	Seattle, Wash.
Group XVII (4)	Stanford University	Stanford University, Calif.
Group XVIII (3)	California Inst. of Tech.	Pasadena, Calif.

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*Note 1: The number in parentheses indicates the number of Student Branches in each group.

Note 2: Details will be published in the April issue of Mechanical Engineering.

N.Y.U. Learns About Army Life

On Jan. 13, a well-attended joint meeting of the N.Y.U. Branch (evening) and the local chapter of the A.S.C.E. had as its guest speaker, Capt. Rolf Eliassen, Corps of Engineers, U. S. Army, who gave a talk on Army life in general, the problems encountered by the Army in its water supply and distribution, and the trials and tribulations of an Army sanitary engineer.

North Carolina State Branch opened its meeting of Jan. 18, attended by 60 members, with the showing of a motion picture on the manufacture of a Chevrolet engine. J. B. Alexander was then presented with a five-dollar bill for having presented the best paper among all members during the past term. The meeting was concluded with the O.W.I. film, "Prelude to War."

North Dakota State Branch met on Jan. 14 for the transaction of regular business. Following this, films on "The Royal Canadian Air Force Training Program" and "Construction of a V-8 Engine" were shown.

Battelle Institute at Ohio State

Elizabeth Izant, newly elected chairman, opened the first session of the term held by Ohio State Branch on Jan. 8. After the discussion of routine business, the chairman introduced E. R. Kaiser, research engineer at Battelle Memorial Institute, who gave an illustrated talk on the history, purpose, and function of the Institute.

Oregon State Branch held the first meeting of the winter term on Jan. 13. Following the business meeting films on "Shaping of Steel" and "Wire Forming" were shown.

Pratt Institute conducted the final meeting of the fall semester on Jan. 27. A group of 50 members and guests witnessed two sound movies, "Magic of Steam" and "We Fight for Victory and We Plan for Peace." L. V. Spinney, a graduate of Pratt and now connected with Allis Chalmers Mfg. Co., answered questions concerning the films.

Purdue Meeting Attracts 200

More than 200 members and guests of Purdue Branch were present at the Jan. 28 meeting. P. E. Perkey of the Studebaker Corp. presented a full-sized working model of the Wright "Cyclone" engine used to power the famous Flying Fortresses. Through the use of cut-away sections and by using an electric motor to drive the engine, the various working parts of the engine were shown in operation.

Rice Branch transacted no business at the Dec. 2 meeting which was held for the showing of films on electric-arc welding.

Stanford Branch made a field trip on Jan. 16 through the Joshua Hendy Iron Works, which is situated about seven miles from the campus. Shown to the boys were many products being manufactured by the company for the Army and Navy.

Tennessee Branch at its meeting of Jan. 20 had Robert Johnson and A. B. Long present a motion picture on "Air Fixtures." After the presentation, Prof. F. H. Thomas, a new member of the faculty, gave a talk on the "St. Louis Arsenal."

Tufts Branch members met on Dec. 29 and heard student member Ralph Long speak on industrial scrap salvage. The talk was interesting and educational.

Virginia Entertains British

Among the guests at the Jan. 12 session of Virginia Branch were two British sailors. Speaker of the evening was the Branch treasurer, Wm. N. Willoughby, formerly with the N.A.C.A., who gave a short introduction to the film, "Study of Airflow by Means of Smoke."

Virginia Poly Branch had Prof. J. B. Jones, head of the mechanical-engineering department at V.P.I., introduce George L. Bascomb, who spoke on "Lubrication" at the Jan. 25 session. Mr. Bascomb, with the aid of several diagrams, explained Reynolds' theory on lubrication, how oil must be introduced to the bearing at a point of minimum pressure, and the analysis points of maximum and minimum pressure in a mechanism.

Washington State Branch nominated members at the Jan. 7 meeting as officers for the coming semester. The meeting was adjourned after the showing of a motion picture on the Grand Coulee Dam.

Washington Branch decided at its Jan. 6 session to hold a banquet sometime during the month. After this business, the members elected officers for the coming semester.

Student Speakers at West Virginia

At the Jan. 4 and Jan. 11 meetings of West Virginia Branch the following papers were presented by student members: "Postwar Recreation," by R. E. Schmidt; "Plastic Airplane," by J. M. Lowdermilk; "Wood Pipe and Its Place Today," by W. Gardner; "Military Bridges," by John Muffly; "Mechanical Preparation of Coal," by J. D. Rowe; "Why Airplanes Fly," by J. M. Haynes; "Development of Timber Connections," by Jack Linville; "Nickels Without Nickel," by Norvale Morris; "New Warfare Optics," by J. B. Powell; "Forced Circulation Boiler," by J. G. Couch; "Vital Cogs," by J. J. Brand; and "Three-Point Suspension Speedboats," by T. McCarthy.

Wisconsin Branch spent the time of its meeting on Jan. 7 in electing officers for the coming semester and making plans for future meetings.

The Navy Needs Engineers

The Navy has issued a call for qualified engineers to fill the new vacancies existing in research, development, inspection, operation, and maintenance of the Navy's mechanical equipment. The Navy's need for these mechanical engineers who have training and experience in the fields of aeronautics and Diesel engineering is considered particularly urgent.

In this emergency, the Navy needs physically qualified men up to 50 years of age, who hold degrees in mechanical engineering and who have practiced in the field of engineering. In lieu of a degree, candidates should have ten to fifteen years' experience in the field of mechanical engineering, evidenced by proof of having had responsible charge of work and a recognized standing in the profession. The Navy announced that men who have less than ten years' experience but who have successfully completed two or more years of college work leading toward an engineering degree also will be given consideration.

Qualified engineers are urged to apply for a commission at the nearest Office of Naval Officer Procurement. These offices are located in principal cities throughout the U. S.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative, nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient, nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

New York
8 West 40th St.

Boston, Mass.
4 Park St.

Chicago
211 West Wacker Drive

Detroit
100 Farnsworth Ave.

San Francisco
57 Post Street

MEN AVAILABLE[1]

Civil and Mechanical Engineer, 40, with 16 years on location and construction of highways, bridges, and pavements up to assistant State highway engineer and general superintendent for contractor; 6 years as chief engineer and production manager on design and manufacture of electroweld sheet, plate, structural-steel units with rotary driers, and power transmission; self-training only. Available at once for responsible position with permanent connection. Me-787.

Mechanical Engineer, recent graduate of Polytechnic Institute of Brooklyn. Anxious

(*A.S.M.E. News continued on page 226*)

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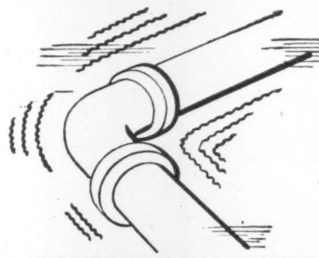
[1] All men listed hold some form of A.S.M.E. membership.

How to eliminate these piping troubles that hamper war work:

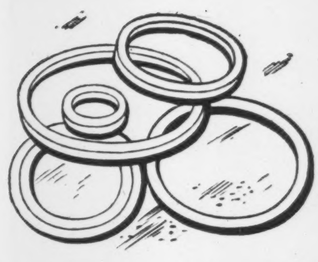
Weld with TUBE-TURN

WELDING FITTINGS



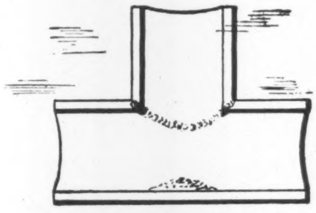
VIBRATION EFFECTS

You need never worry about vibration or strain loosening a *welded* joint.



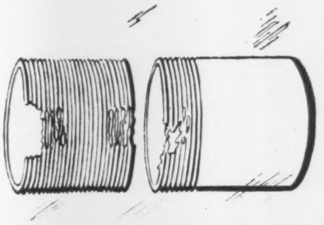
GASKET CHANGES

Fewer flanged joints mean less gaskets—save materials and time.



SLAG ACCUMULATION

Butt welds with Tube-Turn fittings virtually eliminate danger of slag.

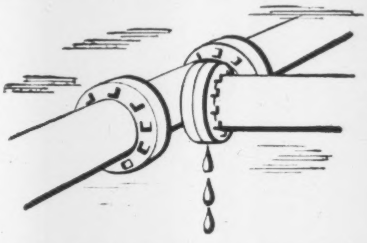


WORN THREADS

Threading thins and weakens metal—causes failures.

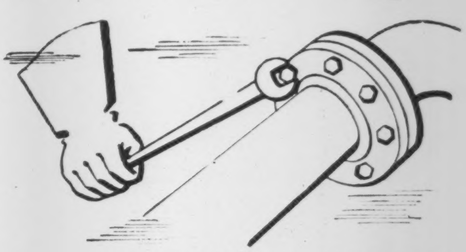
RAPID CORROSION

Tube-Turn fittings resist corrosion because of better metal structure.



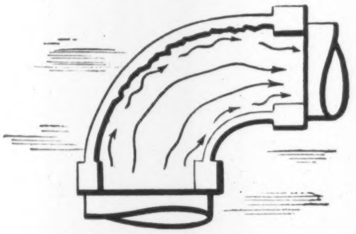
LEAKAGE REPAIRS

No chance of loose connections or leaks with Tube-Turn fittings.



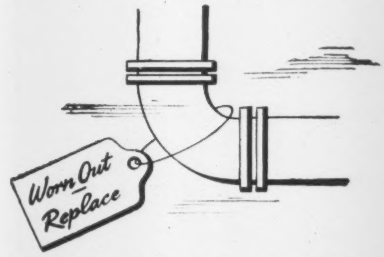
LOOSENED BOLTS

The more welding fittings used, the fewer bolts there are to tighten.



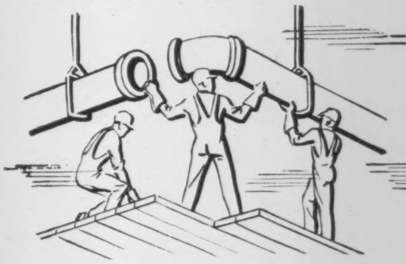
INEFFICIENT FLOW

Easy sweeping radius and no offsets inside mean less pressure loss.



FITTING REPLACEMENT

There's far less time loss or replacement expense with Tube-Turn welding fittings.



SLOW INSTALLATION

Tube-Turn fittings line up perfectly; allow fast, simple, easy butt welding.

NO. 3 OF A SERIES

HOW TUBE-TURN WELDING FITTINGS BENEFIT WAR INDUSTRY

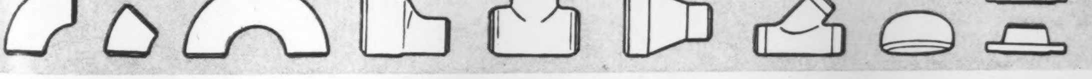
The FIRST WELDING FITTINGS 1ST AND STILL THE BEST

TUBE-TURN

TRADE MARK

Welding Fittings and Flanges

TUBE TURNS (INC.) LOUISVILLE, KY. *Branch offices:* New York, Chicago, Philadelphia, Pittsburgh, Cleveland, Dayton, Washington, D. C., Tulsa, Houston, Los Angeles. *Distributors in principal cities.*



ARMY E NAVY M

to obtain position in power-plant or machine-design field. Draft status 4-F. Not employed at present. Me-788.

Mechanical Engineer, M.E., M.M.E., Cornell graduate, 20 years' experience on design, construction, operation of central steam-power plants. Has made many extensive surveys of private industrial power plants. Also experienced in heating, air-conditioning, and refrigeration. Has professional engineer's license in New York. Me-789.

Development Engineer, designer, 41, married, family, holding responsible position, qualified for position as chief or assistant chief engineer in development work related to high-speed rotary machinery, thermodynamics, hydraulics. Me-790.

Assistant Manufacturing Executive, 36, graduate, extensive experience as assistant works manager, labor, production engineering, material control, tool and mechanical design, sales engineering. Very aggressive. Capable of managing 100 to 200-employee plant. Me-791.

Mechanical Engineer, four degrees, with 13 years' top-caliber experience as professor, consultant, and chief engineer in fields of machine design and metal processing. Interested in change to superior position with industrial organization or professorship at college situated in area offering consulting opportunities. Me-792.

Mechanical Engineer desires supervisory position in a research and development department. Master of science degree and 12 years' industrial experience in the field of mechanical power transmission. Me-793.

POSITIONS AVAILABLE

Plant Superintendent to supervise complete cycle of operations: molding, cleaning, heat-treating, aging and inspection, magnesium castings. Must have actual experience in field. Salary open. Ohio. W-1280-CD.

Works Engineer to supervise all mechanical, electrical, and building maintenance. Should have mechanical-design background. Salary open. Ohio. W-1531-D.

Mechanical Engineers, not necessarily graduates, with good groundwork in fundamentals of mechanics. Should have experience in one or more of following: heat transfer, armaments, gun- or torpedo-installation equipment, hydraulics, aeronautical wing or fuselage, sheet-metal layout; knowledge of mechanisms, strength of materials, or stress analysis. Prefer men with 3 to 5 years' experience on the board; must be over forty. Will be in aeronautical industry. Permanent. Write for application. East. W-1690-BC-D.

A.S.M.E. Calendar
of Coming Meetings

April 26–28, 1943
Spring Meeting
Davenport, Iowa

June 14–16, 1943
Semi-Annual Meeting
Los Angeles, Calif.

June, 1943
Applied Mechanics Division
Carnegie Institute of Technology
Pittsburgh, Pa.

June, 1943
Oil and Gas Power Division
Baltimore, Md.

(*For coming meetings of other organizations see page 29 of the advertising section of this issue*)

Mechanical Engineer, university graduate, with experience in designing and erection of conveying and material-handling equipment. Man must be well qualified to do designing and drafting work which will probably occupy 90 per cent of time in engineering department; remainder utilized in field work. $3600 year. Ohio. W-1748-D.

Industrial Relations Manager with some practical experience in line manufacturing medium-heavy machines; 5 plants; over 10,000 employees. To $10,000 a year. East. W-1750-B-D.

Engineers. (*a*) Foreman-training supervisor for large metal-manufacturing industry. $5000–$6000 year. Upper New York State. (*b*) Production engineer with knowledge and experience in metal manufacturing. Must be able to co-ordinate machine tools, tooling, methods of processing. $4000–$5000 year, plus 25 per cent overtime. N. Y. State. W-1751.

Engineers. (*a*) Time-study and rate-setting engineer to head up department. Must be thoroughly familiar with machine-shop operations. About $4000 year. (*b*) Process engineer with knowledge of machine-shop processing. $5000–$6000 year. Conn. W-1752.

Engineering Accountant to plan and operate all controls, time, materials, schedules, and rate-setting unit costs. Company engaged in making magnesium castings. Salary open. Ohio. W-1754-C-D.

Master Mechanic, 35-50, graduate mechanical engineer, to report to works manager and be responsible for all mechanical equipment used in manufacturing operations. Will be expected to so organize and supervise his work that present production can be doubled, quality greatly improved, and speed of production accelerated. Must have thorough knowledge of medium and light machine tools, dies, jigs, fixtures, tool and special-fixture design, and must be able to make process analysis quickly and accurately from blueprints. Salary open. Middle West. W-1763-CD.

Chief Engineer, 35-50, graduate, to be responsible for all engineering activities (except product engineering) in the various plants. Will be responsible for all engineering records and will examine all requisitions involving capital expenditures for plant or equipment and keep management constantly informed. Should be an accomplished machine designer and know power-plant design from practical operating standpoint. Should have extensive experience in analyzing contemplated plant expenditures to determine their economic justification; also experience in selection and installation of equipment. Salary open. East. W-1764.

Engineers. (*a*) Assistant to vice-president and works manager, 50–55. Must have broad experience in heavy machine shop on the practical side rather than the management or administrative side. Must be able to direct development of production, etc. $10,000 year. (*b*) Production engineer, 40–50, also specialized in heavy machine shop. Experience in: (1) Determining methods of machining; (2) Lay out and design of tools; (3) Renting; (4) Cost estimates; (5) Standards. $7500 year. Connecticut. W-1769-B.

Factory Manager, graduate or equivalent, to supervise metalworking shop now employing about 175 people. Should be thoroughly familiar with machine tools, welding, stamping, production-control methods, factory management, and personnel handling. $5000–$10,000 year. Permanent. Include non-returnable photograph. Pennsylvania. W-1775.

Production-Control Supervisor. Should know how to set up raw-material control, order-follow-up control, parts-in-process control, and finished-storage control, not from any technical knowledge gained over such division, but through actual working knowledge of the entire plant. Should be familiar with and preferably have actual experience in depicting to top management general story of production progress by means of charts, or otherwise. About $5000 year. Conn. W-1781.

Tool Engineer to take charge of product processing and tool-designing department employing about 60 men. Should have wide experience in laying-out methods, of doing work in machine shop (to close tolerances) and in design of tools, jigs, fixtures, etc., to accomplish the methods. Must be able to direct others. Salary open. Upper New York. W-1789.

Project Engineers, graduates, preferably mechanical, to be responsible for engineering problems connected with certain specific aircraft contracts. Tool background helpful, as men will be responsible for tool planning. $3600–$4800 year. Pennsylvania. W-1798.

Industrial Engineer. Prefer man with considerable experience in varied line of industries. Must be thoroughly acquainted with all phases of work, such as time study, standards, job evaluation, plant layouts. Knowledge of wage-incentive systems. Will be responsible for installation of production systems in plants. Should have clear conception of business finance. Splendid opportunity for future. To start, $6000–$8000 year. Headquarters, Connecticut. W-1803.

Mechanical Engineers, 40 or over, for large manufacturing company doing high-production work. Should have experience in one or all of following: production planning, management, industrial control, process engineering, manufacturing methods, expediting or purchasing. Salary open. Must have proof of U. S. citizenship. Write for application blanks. East. W-1808-BC-D.

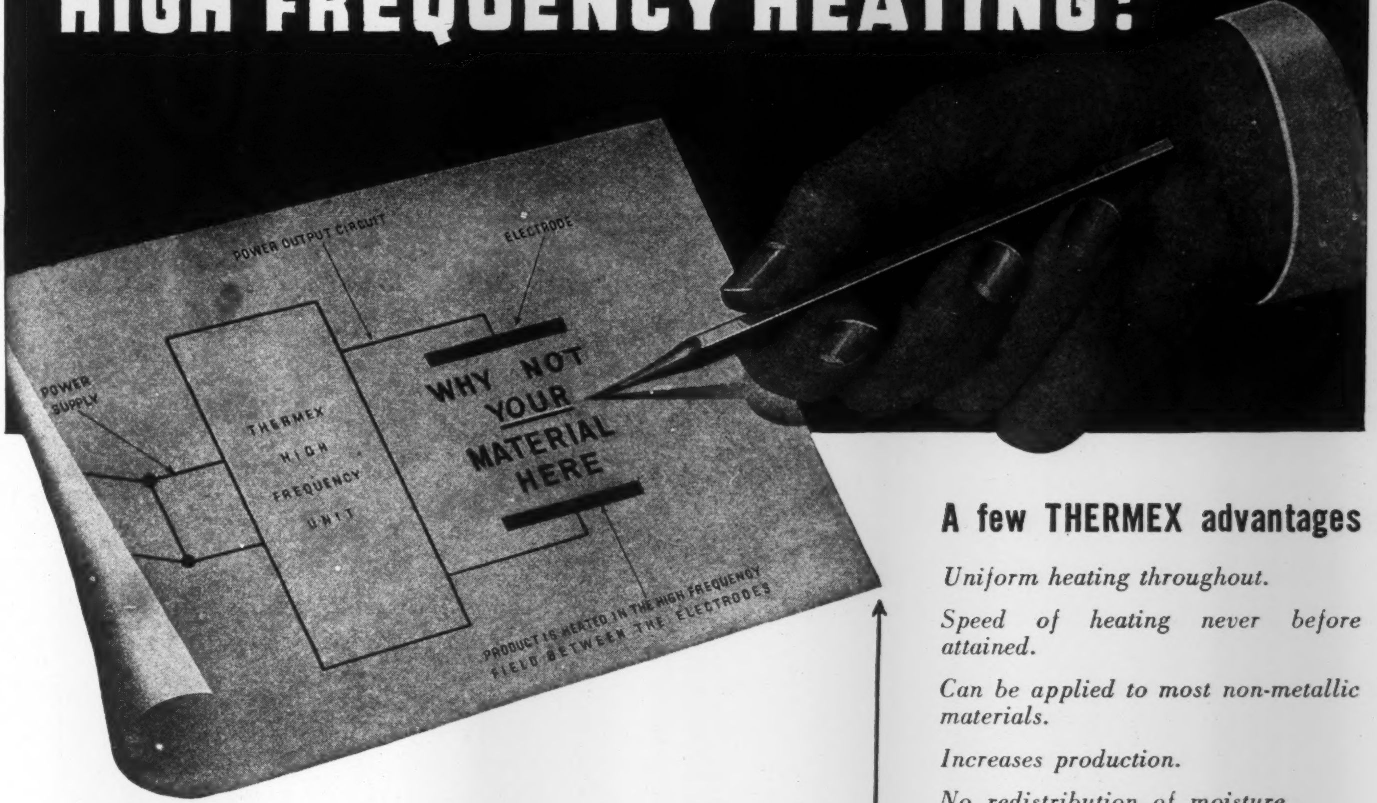
Engineers. (*a*) Director of production, 40–50, familiar with small parts, small machine tools, etc.; watch costs, and control. Ceramic and metals experience desirable. $7500–$8500 year. (*b*) Chief engineer to take charge of drafting room, maintenance, plant layout, inspection, production planning, methods, standards. Practicable experience important. $7500–$8500 year. N. J. W-1825.

Works Manager or Factory Manager and Personnel Manager. (*a*) Works mana-

(*A.S.M.E. News continued on page 228*)

Want faster, uniform drying, bonding or heat processing?

INVESTIGATE THERMEX HIGH FREQUENCY HEATING!


POWER OUTPUT CIRCUIT
ELECTRODE
POWER SUPPLY
THERMEX HIGH FREQUENCY UNIT
WHY NOT YOUR MATERIAL HERE
PRODUCT IS HEATED IN THE HIGH FREQUENCY FIELD BETWEEN THE ELECTRODES

Thermex heats non-conducting materials faster and uniformly

If your production involves drying, heat processing or bonding any non-metallic substance, then you will be vitally interested in Thermex.

Thermex is the *first practical, proved equipment* for industrial use employing high frequency electrostatic heating.

There are so many advantages to this type of heating over all other known methods that you are urged to investigate the possibilities of Thermex in your plant.

Heating is absolutely uniform regardless of the thickness or mass of material. Heat is generated *within the substance* at a rate never before possible. There is full control at all times—heating may be stopped instantly, or increased or decreased by the twist of a dial.

Send for new illustrated booklet describing how Thermex can help war production, its advantages, application, and simple operation. Fill in and mail the handy coupon *now*.

A few THERMEX advantages

Uniform heating throughout.

Speed of heating never before attained.

Can be applied to most non-metallic materials.

Increases production.

No redistribution of moisture.

Less handling required.

Reduces labor costs.

Handles wide variety of jobs with high efficiency.

Results may be reproduced without variation.

No surface damage or danger of overheating.

Heating may be stopped immediately.

No "hot plates" or steam required.

Wide range of sizes for all requirements.

SEND FOR BOOKLET *Now!*

The Girdler Corporation
Thermex Division
219 E. Broadway, Louisville, Ky.

Send us your free booklet on Thermex High Frequency Heating:

Name____________________

Title____________________

Firm____________________

Address____________________

City________________ State________

The GIRDLER CORPORATION

Thermex High Frequency Electrostatic Heating Equipment

THERMEX DIVISION . LOUISVILLE, KENTUCKY